AUG 17 1923
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# ENGINEERING:

## An Illustrated Weekly Journal.

*EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.*

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VOL. CXVI.—No. 3005.] *LONDON: FRIDAY, AUGUST 3, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, page 24.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

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The Strongest Chain in the World.
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Specification and Workmanship equal to Main Line Locomotives.
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**Spencer-Hopwood & Kirke**
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Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

**Æ Tubes, Plates, Rods, &c.,**
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ALLEN EVERITT & SONS, LTD.,
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HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

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for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
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SHIP & LAUNCH BUILDERS, Od 3551
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See page 17, July 27. 1134

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CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
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RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
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—Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1463, Offices of ENGINEERING.

**P. & W. MacLellan, Ltd.,**
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MANUFACTURERS OF
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RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
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**See's** Patent Hydro-Pneumatic **Ash Ejector**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817

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See Advertisement page 69.

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IRON & STEEL
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See Advertisement, page 24. 1111

**Drag Line Excavator.**
Has moved 2,000 cube yards in one day. May be seen at Frodsham, near Chester. Reach 77 ft.; lift four to five tons; speed of working, one to three cuts a minute.
HARRY FAIRCLOUGH, Contractor.
WARRINGTON. 1550

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Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
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Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
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1120
CARELS DIESEL & STEAM ENGINES (LONDON), LTD., Carlton House, Regent Street, London, S.W. 1. Telephone: Regent 3484.

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**Boilers, Tanks & Mooring Buoys**
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

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LIMITED.
See Advertisement page 64, July 27. 3402

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See Full Page Advt., page 59, July 20.

**Taylor & Challen Presses**
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
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**PRESSINGS, STAMPINGS,**
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*British Aluminium Co., Ltd.,*
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Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

## Finsbury Technical College,

LEONARD STREET, CITY ROAD, E.C. 2.

CIVIL AND MECHANICAL ENGINEERING.
Professor H. P. PHILPOT, A.M.Inst.C.E.

ELECTRICAL ENGINEERING.
Professor W. H. ECCLES, D.Sc., F.R.S.

CHEMISTRY.
Professor A. G. HALE, F.I.C.

The College provides practical scientific training for students who desire to become Civil, Mechanical or Electrical Engineers or Chemists.

Candidates are required to pass an Entrance Examination in Mathematics and English, but the Matriculation Certificate of any British University, and certain other qualifications, are accepted in lieu of it. The next Entrance Examination will be held on Tuesday, 18th September. Applications for admission should be forwarded to the College on forms to be obtained from the REGISTRAR. The Programme of the College may be had on application. B 47

## University of Birmingham.

FACULTY OF SCIENCE.

ENGINEERING DEPARTMENTS.

I.—MECHANICAL ENGINEERING.
Chance Professor: F. W. BURSTALL, M.Sc., M.A. (Cantab.), M.Inst.C.E., M.Inst.M.E.
Lecturer: R. C. PORTER, M.Sc. (Vict.) A.M.Inst.C.E.
Demonstrator: S. J. ELLIS, B.Sc., A.M.I.C.E.
Lecturer on Machine Design: F. H. BODEN, B.Sc.
Assistant Lecturer on Machine Design: HENRY BAKER, B.Sc.

II.—CIVIL ENGINEERING.
Beale Professor: FREDERICK C. LEA, M.Sc., D.Sc. (Lond.)., A.M.I.C.E , A.R.C.S.
Lecturers: R. C. Panton, M.Sc.
H. W. COULTAS, M.Sc.
T. H. P. VEAL, B.Sc.
Lecturer on Town Planning: W. HAYWOOD.

III.—ELECTRICAL ENGINEERING.
Professor: WILLIAM CRAMP, D.Sc.
Lecturer: B. J. KIPPS, M.Sc., M.Inst.E.E.
Assistant Lecturers and Demonstrators: O. R. RANDALL, M.Sc.
H. VICKERS, Ph.D., M.Eng.
G. M. HARVEY, B.Eng.

The FULL COURSES EXTEND OVER FOUR YEARS, and students who enter after matriculation and pass successfully the examinations at the end of each year will BE ENTITLED TO THE DEGREE OF BACHELOR OF SCIENCE in Engineering.

THE SESSION 1923-24 COMMENCES ON OCTOBER 1st, 1923.

For detailed syllabus of the Faculty with full particulars of University Regulations, Lecture and Laboratory Courses, Fees, etc., apply to the REGISTRAR. B 229

## University College of SWANSEA.

(A Constituent College of the University of Wales).

APPLIED SCIENCE DEPARTMENTS.

ENGINEERING.
Professor—FREDERIC BACON, M.A. (Cantab.), A.M.Inst.C.E., M.I.Mech.E., M.I.E.E.
Lecturer in Electrical Engineering—R. G. ISAACS, M.Sc. (Bristol), B.Sc. (Lond.), A.M.I.E.E.
Lecturer in Civil Engineering—H. H. BURNESS, M.C., B.Sc. (St. Andrew's), A.M.Inst.C.E., A.M.I.Mech.E.
Assistant Lecturer—J. SELWYN CASWELL.

METALLURGY.
Professor—C. A. EDWARDS, D.Sc. (Manchester).
Lecturer—H. I. COE, M.Sc. (Wales and Birmingham).
Assistant Lecturers—A. L. NORBURY, M.Sc. (Manchester), L. B. PFEIL, B.Sc. (Lond.), A.R.S.M.

The College offers a number of exceptional advantages to Students who aim at entering upon professional careers in Engineering or in Metallurgy. It is situated in the heart of an industrial area, which includes a large number of works of very varied character, and presents an unrivalled variety of metallurgical practice. The manufacturers of the district, who contribute largely to the support of the College, give the Staff and students of the Applied Science Departments every access to the Works, and the Managers, Engineers, and Technical Officials co-operate with the Staff of the College in making visits to Works of practical educational value to the students.

Courses of study are provided (1) for the B.Sc. Degree of the University of Wales in (a) Civil Engineering; (b) Mechanical Engineering; (c) Electrical Engineering; (d) Metallurgy, and (2) for Diplomas of the College in (a) Civil Engineering; (b) Mechanical Engineering; (c) Electrical Engineering, (d) Metallurgy.

Persons who are not desirous of studying for Degrees or Diplomas may attend selected College Classes, provided they satisfy the authorities of the College that they are qualified to benefit by such classes.

Entrance Scholarships will be offered for competition in September, 1923.

Particulars concerning admission to the College, and of the Entrance Scholarships, may be obtained from the undersigned.

EDWIN DREW,
Registrar.

University College,
Singleton Park,
Swansea. B 45

## Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1587

## Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1295


### TENDERS.

## Canal Dredger Required.

Bucket type. Specification and Drawing can be had on application to THE SHEFFIELD AND SOUTH YORKSHIRE NAVIGATION COMPANY, Exchange Street, Sheffield. Fee 10s. 6d., returnable on receipt of *bona fide* Tender. B 233

## The Director-General,

INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, requires:—

1. STEEL BOILER TUBES.
2. COPPER FIREBOX PLATES.
3. AXLEBOXES, cast-steel or malleable cast-iron.

Tenders due on the 24th August, 1923, for Nos. 1 and 3, and on the 21st August, 1923, for No. 2.

Tender Forms obtainable from above. B 245

TO MAKERS OF WHIGHBRIDGES.

THE METROPOLITAN ASYLUMS BOARD invite

## Tenders for Providing and

FIXING a NEW 20 Ton WEIGHBRIDGE at each of the following Institutions:—

Northern Fever Hospital, Winchmore Hill, N.21,
Queen Mary's Hospital, Carshalton, Surrey,
Darenth Training Colony, Dartford, Kent,
Tooting Bec Mental Hospital Extension, Tooting, S.W.17,

in accordance with drawings and specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The drawings, specification, and form of tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4. on and after 10 a.m. on Thursday, 2nd August, 1923, and the drawings, specification and form of tender can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* tender sent in accordance with the instructions on the Form of Tender and after the specification and the drawings have been returned.

Tenders, addressed as noted on the form, must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 29th August, 1923.

(By Order),
G. A. POWELL,
Clerk to the Board. B 228

## Sale of Pumping

MACHINERY at HELL WATH PUMPING STATION, South Camp, Ripon, Yorkshire, by PRIVATE TENDER.

This Machinery consists of:—

Two National Oil Engines, Nos. 1990 and 1991, Horizontal Oil Engines, water cooled, T.O. type, 25 H.P., 260 Revs. per minute, complete with Driving Pulleys 40 in. by 14 in., and blow lamp and spares.

Two Rees Roturbo Pumps, Nos. 4160 and 4161, Turbines on Centrifugal System, belt driven from Engine Pulley, Head 110 ft., Revs. 1250, Galls. per hour 20,000, complete with bed plate pedestals, fast and loose pulleys and striking gear.

Six Cooling Tanks, approx. 400 gallons each.
Two Oil Tanks, " 400 " "
One Water Gauge, reading to 60 lbs. per sq. in., also feet head to 140 lbs. per sq. in.
65 ft. Steam Pipe, ¾ in. diameter.
Two Sluice Valves, 6 in.
Two Guards (Wire) 8 ft. by 4 ft. and 10 ft. by 4 ft.
Two Priming Cocks 1 in.
32 ft. Chequered W.I. Plates, 15 in. wide.
23 ft. " " " 18 in. "
One No. 4 Rotary Hand Pump.
One Receiver fitted with gauge and safety valve for self-starting.
One Compressor fitted with fast and loose pulley.
36 ft. Steam Pipe, ¾ in.

The plant can be inspected on site by prior arrangement with Roads and Communications Officer, R.H Office, North Camp, Ripon.

Tenders in envelopes endorsed in left hand top corner "Tender for Machinery at Ripon," should be addressed to the COMMANDING ROYAL ENGINEER, 13, Wenlock Terrace, York, and should reach that office by Twelve Noon, on Monday, 3rd September. B 234

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

## Tenders are Hereby In-

vited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

SPECIFICATION No. 23/117—
22,000 VOLT INSULATORS.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract, Specification, complete. These charges will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £50 is to be lodged with the Tender.

The Specification may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned, in Melbourne, not later than Noon on 6th October, 1923.

R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. B 123

METROPOLITAN BOROUGH COUNCIL OF FULHAM.

FILTRATION PLANT FOR PUBLIC BATHS.

The Council is prepared to receive

## Tenders for the Supply and

ERECTION of FILTERS and PLANT at the Fulham Public Baths. Specification, Tender Form and Particulars to be obtained of the Superintendent and Engineer at the Baths, Walham Green, S.W. 6.

Tenders, marked "Baths Filtration Plant," to be sent to the Town Clerk, Town Hall, Fulham, S.W.6, not later than Four p.m. on Wednesday, 19th September, 1923.

The Council does not bind itself to accept the lowest or any Tender. B 281

J. PERCY SHUTER,
Town Clerk.

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

## Tenders for:—

360 PAIRS WHEELS AND AXLES.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 2nd August, 1923.

A fee of £1 1s. will be charged for the specification, which is NOT returnable.

Tenders must be submitted not later than NOON on Thursday, 16th August, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary.
B 264

## The Government of

HONG KONG PROPOSE to LAY TRAMWAY TRACKS along certain of the main roads of the Kowloon Peninsula and are PREPARED to GRANT a LEASE for a term of years, for full power of user thereof, for running an efficient electric tramway service thereon. The lessees will be required to electrically equip the track, supply or obtain electrical current, rolling stock, buildings, etc., maintain the trackwork and equipment, and operate the service to the satisfaction of the Government.

Further information can be obtained at the office of THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, to whom British Firms proposing to Tender for the lease are requested to furnish particulars of similar undertakings for which they are or have been responsible, quoting as reference number, Z, Hong Kong 2897. B 249

METROPOLITAN WATER BOARD.

PROVISION OF 7-TON STEAM CRANE—LEA BRIDGE, CLAPTON, N.E.

The Metropolitan Water Board invite

## Tenders for the Supply,

TESTING and SETTING TO WORK of a STEAM DRIVEN LOCOMOTIVE SHUNTING JIB CRANE, of 7-tons capacity, at their Lea Bridge Pumping Station.

Forms of Tender and Conditions of Contract may be obtained on and after Saturday, 21st July, 1923, from the Chief Engineer, New River Head, 173, Rosebery Avenue, E.C. 1., by personal application (Room 155) or upon forwarding a stamped addressed brief envelope.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1." and endorsed "Tender for Crane," must be delivered at the Offices of the Board not later than Eleven a.m. on Friday, 10th August, 1923.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C. 1.
20th July, 1923. B 193

CITY OF DUNDEE.

RAILWAY BRIDGE OVER KINGSWAY.

## Tenders are Invited from

Competent Bridge Contractors for the EXCAVATOR, MASON, STEEL, and other INCIDENTAL WORKS for the above PLATE GIRDER BRIDGE in Two Span of 82 Feet.

Copies of the General Conditions, Specification, Bill of Quantities, and Form of Tender may be obtained and Drawings examined upon application to the Undersigned after SATURDAY, 4th August, on payment of £5 deposit, which will be returned on receipt of a *bona-fide* Tender.

Contractors wishing to be shown over the Site of the proposed works are requested to meet the Engineer at the Site on August 10th, at 2.30 p.m.

Tenders sealed and endorsed "Kingsway Bridge," to be lodged with the TOWN CLERK, City Chambers, Dundee, not later than Ten a.m. on MONDAY, 3rd September, 1923.

The Council do not bind themselves to accept the lowest or any Tender.

GEORGE BAXTER, J.P., M.Inst.C.E.,
City Engineer.

Municipal Offices,
91, Commercial Street, Dundee.
30th July, 1923. B 254

### APPOINTMENTS OPEN.

UNIVERSITY OF ABERDEEN.

CRUICKSHANK LECTURESHIP IN ASTRONOMY AND METEOROLOGY.

The University Court will proceed in autumn to the

## Appointment of a Lecturer

in Astronomy and Meteorology. Salary £800 per annum.

Persons desirous of being considered for the appointment are requested to lodge their names with the Secretary to the University on or before 1st November, 1923, from whom further particulars may be obtained.

H. J. BUTCHART,
Secretary.
The University,
Aberdeen. B 231

MIDDLESEX EDUCATION COMMITTEE. ACTON & CHISWICK POLYTECHNIC.

The Committee invite

## Applications for the Post of

LECTURER in Electrical Engineering—Second year work, for the Winter Session commencing on the 24th September next. Three evenings per week. Salary 19/- per lesson of two hours. Forms of application, which must be returned by Ten a.m. 3rd September, may be obtained on application to V. C. EGERTON, Principal, The Polytechnic, Bath Road, Chiswick, W.4.

B. S. GOTT,
Secretary, Middlesex Education Committee,
40, Eccleston Square, S.W. 1. B 270

CITY OF BRADFORD.

TECHNICAL COLLEGE.

## Applications are Invited for

the APPOINTMENT of ASSISTANT LECTURER in the Department of Civil Engineering, Architecture and Building.

An inclusive salary up to £300 per annum will be paid to a candidate of suitable qualifications and experience. Candidates should possess a good degree in Civil Engineering, and have had practical experience in public works and buildings.

Full particulars of the appointment, and forms of application, may be obtained from the Principal of the College. Applications, endorsed "Assistant Lecturer—Technical College," should be returned to me not later than 18th August, 1923.

N. L. FLEMING, Town Clerk. B 262

UNIVERSITY OF ABERDEEN.

JACKSON CHAIR OF ENGINEERING.

The University Court will proceed in autumn to the

## Appointment of the First

Incumbent of the Jackson Chair of Engineering, the patronage of which is vested in the University.

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## THE LAWS OF HEAT TRANSFER.

(*Continued from page* 70.)

IN presenting Osborne Reynolds' argument on page 2 *ante*, it was pointed out, that owing to the existence of the film in viscous flow along the wall of the pipe, a correction was required, and that the wall temperature which appears in his formula should be replaced by the temperature of the outer surface of the turbulent core, or what is the same thing, by the temperature of the inner surface of the viscous film. Moreover, a particle of the fluid, which owing to the turbulence travels from the centre of the pipe and back again, never has its velocity reduced to zero, as it would if it touched the wall, but only to the velocity of the inner surface of the viscous film. To incorporate these considerations into Reynolds' formula, let us denote the temperature of the surface of the turbulent core by $t_c$ and let $v_c$ represent its velocity. Then by Reynolds' principle the distribution of velocity is similar to the distribution of temperature. We may therefore write:

$$\frac{\Delta v}{v - v_c} = \frac{\Delta t}{t_c - t} \quad . \quad . \quad . \quad \text{(D)}$$

where $v$ and $t$ denote respectively the mean velocity and the mean temperature of the water, at the section considered. In this equation $\Delta v$ represents the amount by which the velocity of flow would be reduced in the distance $\Delta x$ were not fresh momentum continuously generated by the pressure gradient.

The viscous film being always thin, we see from Fig. 4, page 69 *ante*, that we may write:

$$\frac{v_c}{v} = \frac{f}{f_1}$$

where $f$ denotes the actual film thickness and $f_1$ the ideal thickness given by equation (B) *ante*.

Calling this ratio $\phi$, and substituting in (D) we get:

$$\frac{\Delta v}{v\,(1 - \phi)} = \frac{\Delta t}{t_c - t}$$

If we multiply both top and bottom of the left-hand side of this equation by $\frac{\pi d^2}{4} \rho v$ we get

$$\frac{\frac{\pi d^2}{4} \rho v \, \Delta v}{(1 - \phi) \rho v^2 \frac{\pi d^2}{4}} = \frac{\Delta t}{t_c - t}$$

But as shown on page 3 *ante*, the numerator now represents the momentum $\Delta m$ destroyed in the length of pipe $\Delta x$, and following the argument there set forth we get as the necessary modification of Reynolds' formula

$$R_r = (1 - \phi) \frac{v}{F}$$

instead of

$$R_r = \frac{v}{F}$$

Similarly the thermal resistance of the film per sq. cm. is given by

$$R_f = \frac{\phi f_1}{c}$$

where $f_1$ denotes the thickness of the ideal film as determined by equation (B) *ante*, and $c$ is the specific conductivity of the fluid. The total resistance R to the transfer of heat between the tube and the water is, of course, given by

$$R = R_r + R_f.$$

In this connection one difficulty arises. Both $R_r$ and $R_f$ involve F as a factor, F being the wall friction expressed in dynes per square centimetre, and as Lees' formula shows, this wall friction depends upon the viscosity of the fluid. When a fluid is picking up heat, however, its temperature and consequently its viscosity varies from the centre to the surface of the pipe, and the question arises what value is to be chosen for $\mu$ in Lees' formula. Direct experiment on this matter is highly desirable, but in the meantime we can get some useful indications by considering the ideal case of turbulent flow represented in Fig. 4, page 69 *ante*.

Let us assume that the core in this ideal case has a viscosity corresponding to the mean temperature of the water at the section considered. The mean viscosity of the viscous film is, however, much less than this, and if for example we assume that it is half as much as that of the core we see that other things being equal the discharge for a given loss of head would be doubled. Other things do not, however, remain equal, since the lower viscosity means that the film will be thinner than if it had the same viscosity as the core, and from equation (B), page 69 *ante*, we see that to a first approximation the thickness will vary directly as the viscosity. Hence the one effect approximately cancels out that due to the other and for a stated discharge the value of F will, to a first approximation, be found by inserting in Lees' formula a value of $\mu$ equal to the mean viscosity of the water at the section considered. As already observed, direct experiments on this matter are desirable, but the foregoing argument cannot involve any really large error.

We are now in a position, by comparision with experiment, to determine the value of $\phi$, *i.e.*, the ratio of the real thickness of a film to its ideal value, and we shall anticipate matters by stating that the result shows that $\phi$ is sensibly constant and equal to 0·55. From certain *a priori* considerations, it might have been expected that the value of $\phi$ would vary with the conditions, and be larger for speeds of flow near the critical than for higher speeds. The experimental evidence, however, indicates that this is not the case, and that $\phi$ is constant and equal to 0·55.

Very few experiments have been made in which tube wall temperatures have been measured, and in those cases in which the total resistance to heat transfer from steam to water has been determined, it is but seldom that the attempt has been made to secure air-free steam. As is well known the resistance on the steam side of a tube varies enormously with the air content, hence hardly any experiments of this kind are of service in such an inquiry as the present.

We are, in fact, confined to those experiments of Mr. Webster in which the wall temperature did not exceed the critical limit, and to a few careful experiments by Mr. J. A. Smith, of Melbourne, in which special pains were taken to secure air-free steam. Fortunately these experiments between them cover values of $\frac{\rho v d}{\mu}$ ranging from 3,800 up to 51,000, which is amply adequate for the end in view. The two sets of independent observations prove to be in really remarkable accord.

In all, Mr. Webster made some 23 experiments in which the wall temperatures were below or but slightly exceeded Reynolds' critical figure of 174 deg. F. One difficulty in reducing these experiments lies in the fact that the temperature rise was in all cases large, and hence it would be unsatisfactory to work with mean water temperatures and mean rates of heat transfer. We shall use instead, the mean water temperature at the mid length of the tube, and the rate of heat transfer at that section. The means for determining these desiderata from Webster's observations are provided by Professor Loeb's determination of the temperature gradient along a 20-ft. tube, which were made in conditions closely corresponding to those ruling in Mr. Webster's experiments. Professor Loeb's research was described in the May issue of the Journal of the American Society of Naval Architects for 1915. He jacketted a 4-ft. tube with steam at a temperature of 228 deg. F., and passed water through the tube at a speed of about 4 ft. per second. Starting with water at a temperature of 55·6 deg. F., he determined its temperature on discharge and then repeated the experiment by preheating the water to this temperature, before again admitting it to his tube. Proceeding in this way he got the results tabulated below:—

TABLE I.—*Temperature Gradient in ¾-In. Copper Tube Outside Diameter of Tube, ¾ In.; Inside Diameter, 0·655 In.; Length, 4 Ft.*

| Number. | Steam Temperature. | Water Temperature. | | Weight Passed, Lb. per Hour. |
|---|---|---|---|---|
| | | Inlet. | Outlet. | |
| | deg. F. | deg. F. | deg. F. | |
| 1 | 228·4 | 55·6 | 93·4 | 2,070 |
| 2 | 228·0 | 93·2 | 125·2 | 2,095 |
| 3 | 228·4 | 125·1 | 152·3 | 2,106 |
| 4 | 228·1 | 152·5 | 173·4 | 2,120 |
| 5 | 227·3 | 174·4 | 189·8 | 2,106 |

It will be seen that the inlet temperature was not in all cases absolutely identical with the discharge temperature in the preceding experiment, nor was the weight of water passed per hour exactly the same in all cases. The deviations are, however, so small that the necessary corrections can be made by approximate empirical formulas, and we can then derive from Professor Loeb's observations a reliable interpolation formula giving the temperature at intermediate points, and permitting the temperature gradients at such points to be calculated.

In choosing the form of such a formula, we are guided by the consideration that were the resistance to heat flow constant from end to end of the tube we should have a formula of the following type, between the water temperature at any point $t$, and the distance $x$ of this point from the origin

$$\log (t_s - t) = a + b\,x.$$

Here $t_s$ denotes the steam temperature and $a$ and $b$ are experimental constants applicable to the particular case considered. We know, however, that the resistance to the heat flow is not constant, and to provide for this we assume that we may write

$$\log (t_s - t) = a + b\,x + c\,x^2 + d\,x^3 \quad . \quad \text{(E)}$$

choosing the coefficients on the right so as to fit the corrected experimental figures.

In this way we get as the most probable values of the temperature at different points (had the mass flow been exactly constant) the figures given in the annexed table, in which it will be seen it has been thought legitimate to make a small extrapolation beyond the experimental range.

In the fourth column are given the values of $\frac{dt}{dx}$ expressed in C.G.S. units, these values being deduced from formula (E):—

TABLE II.—*Temperatures and Temperature Gradients along a 22-Ft. Tube of ¾-In. External Diameter, No. 18 S.W.G. Thick, passing Water at the rate of 2,100 Lb. per Hour.*

| Distance, Ft. | Water Temperature $t$, Deg. F. | Values of $\frac{dt}{dx}$ C.G.S. Units. Cent. Deg. | Distance, Ft. | Water Temperature $t$, Deg. F. | Values of $\frac{dt}{dx}$ C.G.S. Units. Cent. Deg. |
|---|---|---|---|---|---|
| 0 | 35·37 | 0·1879 | 12 | 139·37 | 0·1215 |
| 2 | 55·60 | 0·1804 | 14 | 152·00 | 0·1086 |
| 4 | 74·88 | 0·1708 | 16 | 163·24 | 0·0963 |
| 6 | 93·05 | 0·1596 | 18 | 173·16 | 0·0846 |
| 8 | 109·87 | 0·1475 | 20 | 181·18 | 0·0737 |
| 10 | 125·33 | 0·1345 | 22 | 189·36 | 0·0637 |

To apply this table to the reduction of Webster's experiments, curves were plotted showing the water temperature and the value of $\frac{dt}{dx}$ for corresponding values of $x$.

Taking, for example, Webster's experiment No. 35, the inlet and discharge temperatures were 45·2 deg. F. and 83 deg. F., respectively. The corresponding values of $x$ in Loeb's curve are $x_0 = 0{\cdot}95$ ft. and $x_1 = 4{\cdot}90$ ft. At the mid point the temperature as read from the curve is 64·7 deg. F. = 18·2 deg. C., and the corresponding value of $\frac{dt}{dx}$ is 0·1713. Hence, since Mr. Webster's tube was 2½ ft. long, we get the following value of $\frac{dt}{dx}$ for experiment No. 35, viz.:—

$$\frac{dt}{dx} = 0{\cdot}1713\,\frac{4{\cdot}90 - 0{\cdot}95}{2{\cdot}5} = 0{\cdot}2707 = \text{C.G.S. units.}$$

Now let $q$ be the rate of heat flow at mid length of Webster's tube expressed in calories per square centimetre per second. In the short length $\Delta x$ the total heat entering the tube is then $q\,\pi\,d \times \Delta x$ calories per second. In the same distance the water has its temperature raised by $\Delta t$, and the weight passing is $\frac{\pi d^2}{4} \rho v$ grammes per second, where $\rho$ denotes the density of the water which may be taken as unity and $v$ the speed of flow in centimetres per second.

Assuming that the specific heat is also unity, the heat absorbed by the water in the distance $\Delta x$ is

$$\frac{\pi d^2}{4} \rho v \, \Delta t.$$

Equating this to the total heat which has passed through the element of the tube we get

$$\frac{\pi d^2 \rho v}{4} \Delta t = q\,\pi\,d\,.\,\Delta x$$

whence

$$q = \frac{\rho v d}{4} \cdot \frac{dt}{dx}.$$

TABLE III.—Webster's Experiments on Heat Transfer (Transactions of the Institution of Engineers and Shipbuilders in Scotland, 1913).

Tube, 2 ft. 6 in. long; internal diameter, ½ in. = 1·27 cm.; tube temperature measured by thermo-couples. Only those experiments have been included in which the tube temperature was below, or very little above, the critical temperature of 174 deg. F.

| Experiment No. | Water Passed. Lb. per Min. | Temperature of Water. Inlet. deg. F. | Outlet. deg. F. | Mid-Length. deg. C. | $\frac{dt}{dx}$ at Mid-Length C.G.S. Units. Centigrade Deg. | Tube Temperature $t_t$ Deg. C. | Heat Flow at Mid-Length, Calories per Sq. Cm. per Sec. | Total Resistance R to Heat Transfer from Wall to Water. C.G.S. Units. | Convective Resistance to Heat Transfer $= 0·45 \frac{v}{F} = R_r$. C.G.S. Units. | Thermal Resistance of Viscous Film $R_f = R - R_r$ C.G.S. Units. | Values of $\frac{0·635}{0·0014} \left\{1 - \sqrt[4]{1 - \frac{8 \mu v}{d F}}\right\}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | 23·85 | 45·2 | 83·0 | 18·2 | 0·2707 | 81·1 | 12·23 | 5·144 | 0·918 | 4·226 | 7·95 |
| 36 | 50·1 | 46·0 | 69·2 | 14·2 | 0·1657 | 67·2 | 15·73 | 3·370 | 0·517 | 2·853 | 5·26 |
| 37 | 82·3 | 45·5 | 63·1 | 12·4 | 0·1242 | 57·5 | 19·36 | 2·330 | 0·350 | 1·980 | 3·94 |
| 46 | 37·4 | 45·0 | 75·2 | 15·7 | 0·2143 | 76·7 | 15·18 | 4·019 | 0·650 | 3·369 | 5·98 |
| 50 | 37·1 | 43·5 | 75·5 | 15·4 | 0·2286 | 78·2 | 16·07 | 3·909 | 0·653 | 3·256 | 5·91 |
| 51 | 61·8 | 42·8 | 64·8 | 12·2 | 0·1568 | 64·6 | 18·36 | 2·854 | 0·436 | 2·418 | 4·63 |
| 58 | 19·73 | 45·7 | 85·2 | 18·9 | 0·2796 | 80·7 | 10·45 | 5·914 | 1·069 | 4·845 | 9·20 |
| 59 | 20·95 | 45·0 | 85·1 | 18·7 | 0·2846 | 82·6 | 11·30 | 5·655 | 1·021 | 4·634 | 8·67 |
| 61 | 54·8 | 44·0 | 70·7 | 14·2 | 0·1917 | 69·1 | 19·90 | 2·750 | 0·483 | 2·276 | 4·77 |
| 72 | 32·6 | 45·1 | 73·3 | 15·2 | 0·2011 | 72·2 | 12·42 | 4·589 | 0·719 | 3·870 | 6·95 |
| 76 | 48·4 | 45·0 | 71·6 | 14·7 | 0·1891 | 72·1 | 17·34 | 3·310 | 0·533 | 2·777 | 5·14 |
| 81 | 63·8 | 45·5 | 68·0 | 13·8 | 0·1591 | 70·9 | 19·23 | 2·970 | 0·429 | 2·541 | 4·25 |
| 8 | 33·2 | 46·5 | 79·2 | 17·3 | 0·2332 | 80·0 | 14·67 | 4·275 | 0·719 | 3·556 | 6·34 |
| 30 | 48·0 | 44·8 | 72·7 | 14·9 | 0·1986 | 75·0 | 18·06 | 3·328 | 0·536 | 2·792 | 5·03 |
| 63 | 43·8 | 44·7 | 76·0 | 15·9 | 0·2232 | 80·0 | 18·52 | 3·461 | 0·578 | 2·883 | 5·15 |
| 82 | 69·1 | 45·4 | 71·1 | 14·7 | 0·1821 | 76·4 | 21·78 | 2·833 | 0·435 | 2·398 | 4·04 |
| 28 | 72·7 | 45·0 | 69·2 | 14·0 | 0·1722 | 70·5 | 23·73 | 2·381 | 0·389 | 1·992 | 3·79 |
| 29 | 47·6 | 44·6 | 75·9 | 15·9 | 0·2226 | 79·4 | 20·07 | 3·164 | 0·543 | 2·621 | 4·81 |
| 52 | 61·8 | 42·9 | 69·3 | 13·5 | 0·1874 | 72·8 | 21·94 | 2·703 | 0·439 | 2·264 | 4·23 |
| 65 | 64·3 | 45·0 | 75·2 | 15·8 | 0·2150 | 79·4 | 26·18 | 2·430 | 0·432 | 1·998 | 3·80 |
| 21 | 73·0 | 45·7 | 72·0 | 15·1 | 0·1866 | 74·8 | 25·80 | 2·314 | 0·390 | 1·924 | 3·61 |
| 64 | 62·6 | 43·9 | 73·9 | 15·1 | 0·2138 | 78·3 | 25·35 | 2·493 | 0·439 | 2·054 | 3·94 |
| 77 | 48·6 | 45·3 | 76·7 | 16·3 | 0·2235 | 80·2 | 20·58 | 3·105 | 0·536 | 1·973 | 4·71 |

It is this quantity which has been entered in column 8 of Table III. Dividing it by the difference between the wall temperature and the water temperature, we get 5·144 as the value of R, the total resistance to heat transmission from the tube to the water. This is entered in column 9 of the table.

The value of $R_r$ column 10, has been calculated from the expression

$$R_r = (1 - \phi) \frac{v}{F} = 0·45 \frac{v}{F}$$

whilst in the last column we have values of $\frac{f_1}{a} \times \frac{a}{0·0014}$ calculated by the aid of the formula

$$\frac{f_1}{a} = 1 - \sqrt[4]{1 - \frac{8 \mu v}{d F}}$$

where $\bar{\mu}$ denotes the mean viscosity of the film. This mean viscosity was determined by Cote's rule for approximate integration, which may be written as

$$\bar{\mu} = \frac{\mu_0}{6} + \frac{2}{3} \mu + \frac{\mu_t}{6}$$

where $\mu_0$ denotes the viscosity corresponding to the outer surface of the turbulent core and $\mu_t$ the viscosity corresponding to the wall temperature, whilst $\mu_{\frac{1}{2}}$ is the viscosity corresponding to the temperature of the film at mid thickness, which is sensibly equal to $\frac{1}{2}(t_t + t_0)$.

The value of $t_0$ is given by the expression

$$t_0 - t = (1 - \phi) \frac{q v}{F}$$

where $t$ denotes the water temperature at mid-length. The value of $\frac{v}{F}$ is, as already explained, found from Lees' formula, taking the value of $\mu$ as that corresponding to the mean water temperature at mid-length.

Had the film had its ideal thickness $f_1$, its resistance would be equal to

$$\frac{f_1}{a} \times \frac{a}{0·0014}$$

In this case the radius $a$ of the tube was 0·635 cm., and hence

$$R_f\Big]_1 = 453·6 \frac{f_1}{a}.$$

values of this will be found in the last column of Table III.

The actual film resistance is found by substracting $R_r$ (column 10) from the total resistance R (column 9), and we thus get the values inserted in the last column but one of the table. Plotting this actual film resistance against the "ideal" film resistance tabulated in the last column we get Fig. 5, where the ratio $\phi$ of the two is seen to be sensibly equal to 0·55, which is the assumption from which we started. Actually this value was arrived at by making a series of such plots with different assumptions as to the value of $\phi$, and thus by a system

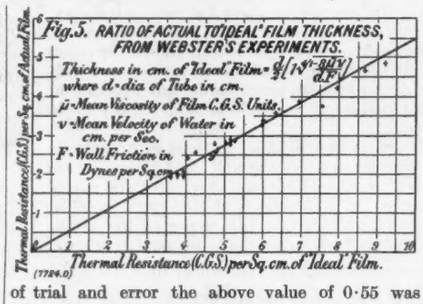


Fig. 5. RATIO OF ACTUAL TO IDEAL FILM THICKNESS, FROM WEBSTER'S EXPERIMENTS.
Thickness in cm. of Ideal Film = $\frac{d}{2}\left(1 - \sqrt[4]{1 - \frac{8\bar{\mu}v}{dF}}\right)$
where d = dia of Tube in cm.
$\bar{\mu}$ = Mean Viscosity of Film C.G.S. Units.
v = Mean Velocity of Water in cm. per Sec.
F = Wall Friction in Dynes per Sq. cm.
Thermal Resistance (C.G.S.) per Sq. cm. of Actual Film.
Thermal Resistance (C.G.S.) per Sq. cm. of Ideal Film.
(7724.0)

of trial and error the above value of 0·55 was attained.

In this set of experiments the greatest thickness of the film was less than $\frac{1}{100}$ of the radius, hence its conductivity or, conversely, its thermal resistance, can be calculated as if it were flat, no correction being required for the curvature. In ordinary condenser practice, however, the film is much thicker and may be as much as one-twentieth of the radius, in which case its resistance would be about 2½ per cent. more than if it were flat.

It is unfortunate that the conditions in Mr. Webster's experiments did not correspond more closely to condenser conditions, and without additional data it would be rash to extrapolate the value found for $\phi$ to conditions in which the water speed was not much in excess of the critical value.

To some extent the want of further data is supplied by certain experiments made by Mr. J. A. Smith, described in a paper read before the Victorian Inst. of Eng., and reprinted in Engineering, March 23, 1906. Mr. Smith used a gas fired boiler the steam space of which was traversed by a condensing tube about 6 ft. long, the internal diameter of which was 1·46 cm.

The importance of these experiments lies in the care taken to secure air free steam. By adjusting the gas jets it was possible to maintain any desired temperature inside the boiler, whatever the rate of flow through the cooling tube.

In one series of experiments, the steam temperature chosen was 110 deg. F. = 43⅓ deg. C., and the rate of flow through the tube was varied in steps from 2½ lb. per minute up to 15 lb. per minute. When the flow was 2½ lb. per minute the motion of the water was non-turbulent, and this experiment must accordingly be ignored.

Mr. Smith made, moreover, some measurements on the temperature gradient of the cooling water, and showed that at mid-length the temperature was in close accord with the formula

$$\log (t_s - t) = a - b x.$$

The temperature thus found is about 1 deg. F. lower than the figure derived from the Loeb curve, but there is a compensating difference in the value of $\frac{dt}{dx}$, so that the total resistance to heat flow at mid-length proves to be identically the same whether we derive it from the Loeb curve or from the above formula. The value of $\frac{v}{F}$ is not materially affected by a difference of 1 deg. F. in the water temperature, so that it is immaterial which of the alternative figures we take in comparing Mr. Smith's results with the formula from Webster's experiments.

The steam being air-free the resistance on the steam side of the tube is known from Callendar's experiments (*Enc. Brit.*, vol. xiii, page 151) to be 2·5 C.G.S. units. The resistance of the tube wall is about 0·17 C.G.S. units, so that the total resistance from the steam to the internal wall of the tube is 2·67 units per square centimetre of tube surface. If $q$ be the heat flow in calories per second per square centimetre of the internal surface of the tube at mid-length then the corresponding temperature drop (Centigrade units) may be taken as $2.45\,q$ since the ratio of the internal to the external diameter of the tube was almost 0·92. We can thus determine the temperature of the tube wall at mid-length and can then calculate $R_f$ as before from the formula

$$R_f = \frac{·730 \times 0·55}{·0014} \cdot \left\{1 - \sqrt[4]{1 - \frac{8 \bar{\mu} v}{d F}}\right\}.$$

A correction for the curvature of the film is, however, required in this case, since its thickness is no longer negligible compared with the tube radius. This correction has been made for the values of $R_f$ entered in the table below:—

TABLE IV.—*Smith's Experiments on Heat Transfer* (*Victorian Institute of Engineers* 1905.)

Steam temperature, 110 deg. F.; initial temperature of cooling water, 69·5 deg. F.; brass tube of 74·9 in. effective length; internal diameter, 0·5753 in. Steam nearly air free.

| Experiment No. 1 .. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Water passed, lb. per minute .. .. | 5·0 | 7·5 | 10·0 | 12·5 | 15·0 |
| Velocity of flow, ft. per second .. | 0·74 | 1·11 | 1·48 | 1·82 | 2·22 |
| Discharge temperature of water, deg. F. .. .. .. | 89·6 | 87·6 | 86·1 | 84·8 | 83·8 |
| Mean water temperature at mid-length, deg. C. .. .. | 26·6 | 26·1 | 25·5 | 25·2 | 24·9 |
| Heat flow at mid-length, calories per sq. cm. per sec. = $q$ | 0·4940 | 0·6659 | 0·8132 | 0·9381 | 1·054 |
| Tube temperature at mid-length, deg. C. | 42·11 | 41·69 | 41·33 | 41·02 | 40·74 |
| Convective resistance $R_r = 0·45 \frac{v}{F}$ C.G.S. units .. .. | 3·86 | 2·88 | 2·34 | 1·98 | 1·73 |
| Calculated thermal resistance of viscous film, C.G.S. units .. .. | 28·97 | 20·93 | 16·71 | 14·04 | 12·21 |
| Total calculated resistance, wall to water .. .. | 32·83 | 23·81 | 19·05 | 16·02 | 13·94 |
| Observed resistance, wall to water .. | 31·25 | 23·40 | 19·40 | 16·88 | 15·00 |
| Ratio of film thickness to tube radius $\frac{f}{a}$ .. .. .. | 0·054 | 0·039 | 0·031 | 0·027 | 0·023 |

The concord between calculation and observation appears to be about as good as could be expected, in view of the fact that the experiments were made without any theoretical guidance as to what it was most important to observe. It is to be hoped that further experiments will soon be undertaken analogous to those of Mr. Webster, but made in a closer agreement with condenser conditions.

It will be seen from Table IV that at the higher rates of heat transfer there is a tendency for the small discrepancy, between observation and calculation, to increase. This may well be the effect of residual traces of air in the apparatus. In Mr. Smith's experiments there was no current over the condensing surface, and the condensation took place accordingly under almost static conditions. Hence even minute traces of air would tend to collect round the tube and the "blanket" thus formed would be thicker the higher the rate of condensation. Hence there would be a tendency for the thermal resistance on the steam side of the tube to increase as the rate of condensation rose.

*(To be continued.)*

# THE CONTACT AREA OF AN ELASTIC SPHERE WHEN COMPRESSED BETWEEN FLAT ELASTIC PLATES.

## AN EXPERIMENTAL DETERMINATION.

By JOHN GOODMAN, M.Inst.C.E., Emeritus Professor of Engineering, The University, Leeds.

WHEN a steel ball is placed between two loaded parallel flat steel plates, the ball is flattened at the points of contact and the plates are indented. Provided the stress is not excessive, the ball and plates entirely recover their original form on removal of the load. The amount the plates approach one another when subjected to a given load is the subject of another investigation by the author. This experimental investigation showed that the approach is somewhat greater than Hertz's theory indicates. By the same theory the areas in contact between the ball and the plates can be arrived at. The accuracy of the theory has been questioned, hence it was thought desirable to get experimental data bearing on this question in order to show how near the theory may be trusted.

*Fig. 1.*

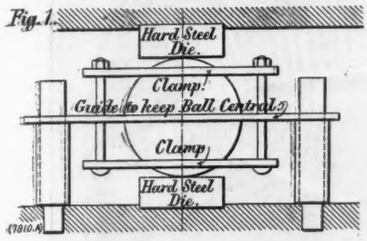
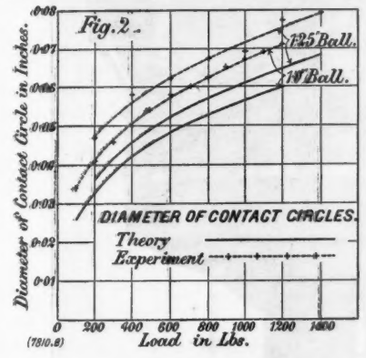



*Fig. 2.*




*Methods of Ascertaining the Area in Contact.*—(1) A rough method of measuring the area in contact between a ball and the plates is to smear the ball with thin paint or other material, and measure the area of the paint spot on the flat plate. But however thin the coat of paint may be this method will always give too large a value for the surfaces in contact.

(2) Another method is to use a perfectly clean ball and plates, and when the ball is under pressure to etch the surface of the plate surrounding the contact area with weak acid applied by a fine brush. The acid does not penetrate the two surfaces in contact, consequently, when the ball and dies are separated a clearly-defined contact area is revealed. This gives quite a good result, and appears to be the only way when the plates are not flat. For example, when a ball is pressed into a grooved ring such as is commonly used in ball bearings.

(3) If the plates are electrically insulated from the testing machine, the area in contact between the ball and plates may be obtained indirectly by passing a current of electricity through the plates and ball and measuring the electrical resistance from which the areas in contact may be arrived at. But it is very difficult to get regular and consistent results by this method.

(4) The method used by the author is very simple and easy to carry out for flat plates. When under pressure the ball is rotated about its loaded axis, the areas in contact acting as pivots, on removing the ball from the machine, the circular areas which have been rubbing on the plates are plainly marked, and their diameters can be readily measured under a measuring microscope. To ensure the ball rotating about its loaded axis, a closely-fitting template was held in position as shown in Fig. 1. A clamp attached to the ball provided a means of rotating it when under load.

*Results of the Tests.*—The results of the tests show that the areas in contact between the ball and the plates are greater than Hertz's theory indicates. When the investigation was started it was expected that the contact areas of large balls would be found to bear a greater proportion to the calculated areas than in the case of small balls, because the former are probably not hardened right to the core and, consequently, flatten more under load. This, however, has not proved to be the case. The ratios of the experimental to the calculated diameters of the surfaces in contact are as follows:—

*Fig. 3.*

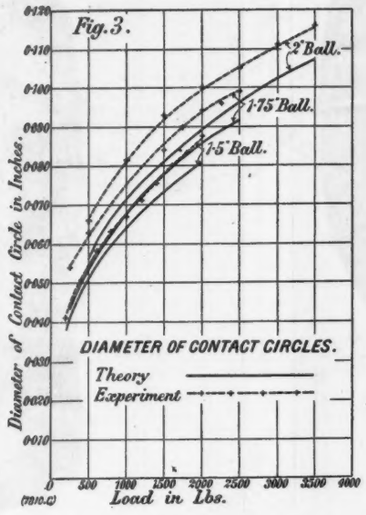
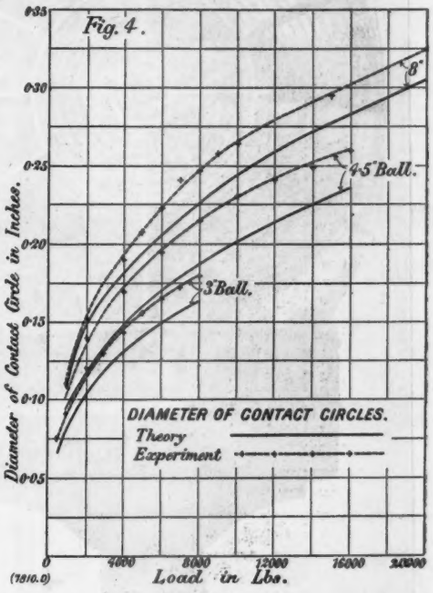



*Fig. 4.*




| Diameter of ball (In.) | 8 | 4·5 | 3 | 2 | 1¾ | 1½ | 1¼ | 1 |
|---|---|---|---|---|---|---|---|---|
| Experimental area in contact / Calculated area in contact | 1·07 | 1·14 | 1·13 | 1·13 | 1·12 | 1·06 | 1·21 | 1·21 |

The mean value being 1·13, or the actual area in contact between the plates and balls is 13 per cent. greater than theory indicates, or the mean compressive stress on the balls is 13 per cent. less than theory indicates.

*Hertz Theory.*—From Hertz's theory we have

$$S = 40{,}000 \sqrt[3]{\frac{P}{d^2}} \text{ for flat plates.}$$

Where S is the mean compressive stress in pounds per sq. inch on the areas in contact.
P is the load in pounds.
$d$ is the diameter of the ball in inches.
$d_c$ is the diameter of the contact circle in inches.

hence

$$S = \frac{40{,}000\, P^{\frac{1}{3}}}{d^{\frac{2}{3}}} = \frac{P}{\text{Area of contact}}$$

$$\frac{40{,}000\, P^{\frac{1}{3}}}{d^{\frac{2}{3}}} = \frac{P}{0{\cdot}7854\, d_c^2}$$

$$d_c = 0{\cdot}00564 \sqrt[3]{d\, P}$$

The maximum safe load in pounds according to Stribeck is

$$P_{max.} = 700\, d^2 \text{ for flat plates.}$$

When the maximum safe load is reached

$$d_c = 0{\cdot}00564 \sqrt[3]{700\, d^3}$$

$$d_c = \frac{d}{20}.$$

According to Hertz's theory, the maximum compressive stress in the centre of the contact area (*i.e.*, one and a half times the mean), when the maximum safe load is reached, is 240 tons per square inch. But the present investigation leads to a somewhat lower value, namely, about 210 tons per square inch.

It is remarkable that such an enormous stress as this can be applied to and removed from the material in a steel ball for hundreds of millions of times without producing fracture, but such is the case.

The author wishes to acknowledge with thanks the help he has received from:—

(i) The Board of Scientific and Industrial Research for financial assistance in providing an assistant and for the purchase of apparatus.

(ii) The Hoffmann Manufacturing Company, and the Skefko Ball Bearing Company, for the loan and gift of balls for experimental purposes.

(iii) Messrs. Brown, Bayley and Co., of Sheffield, for the gift of compression dies.

# THE NEW LIGHT AT PORT SAID.

To Egypt belongs the credit of the erection of the first lighthouse on record, namely, the tower built on the island of Pharos at the mouth of Alexandria Harbour, by that most enlightened ruler Ptolemy II. about 660 years before the Christian era. This tower was 100 ft. high and stood as a monument to an ancient civilisation until the fourteenth century, when it was washed away by the sea. Its light consisted of an open fire of burning wood, and the same practice was followed in all subsequent lighthouses until the beginning of the seventeenth century. Even as late as 1790 the South Foreland lighthouse was merely a beacon-fire of coal. The famous Eddystone lighthouse, in 1759 was lit by 10 lb. of tallow candles, a clock being provided to ring a bell every half-hour to remind the keeper to snuff them. In 1763 oil lamps with reflectors were used for the lighting of the Mersey Channel, and after the invention of the Argand burner twenty years later oil became the standard illuminant. Mineral oil was introduced in 1872, and the concentric wicks of the Argand burner in due course gave way to the incandescent mantle, which now furnishes the light for all the most important lighthouses of the world.

The optical apparatus of lighthouses is divided into four standard "orders" of size according to the nature of the duties which the light has to fulfil. The smallest standard light, which is said to be of the fourth order, has a mantle 35 mm. in diameter and gives 612 candle-power with a consumption of 0·66 pints of oil per hour. After the intermediate sizes of 1,200 candle-power and 2,500 candle-power,

# NEW HARBOUR LIGHT FOR PORT SAID.

CONSTRUCTED BY MESSRS. CHANCE BROTHERS AND CO., LIMITED, ENGINEERS, BIRMINGHAM.

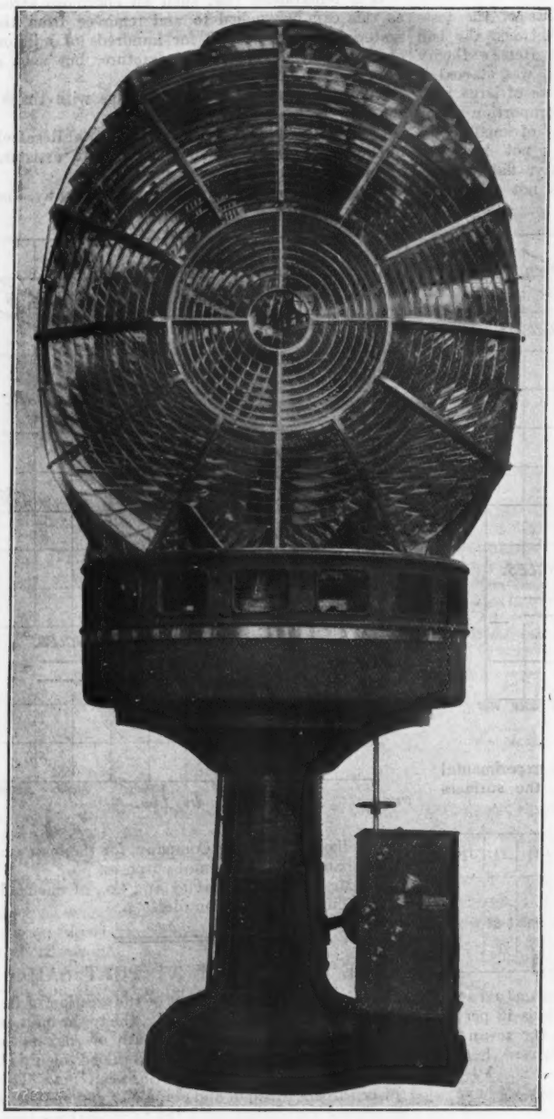


Fig. 1.

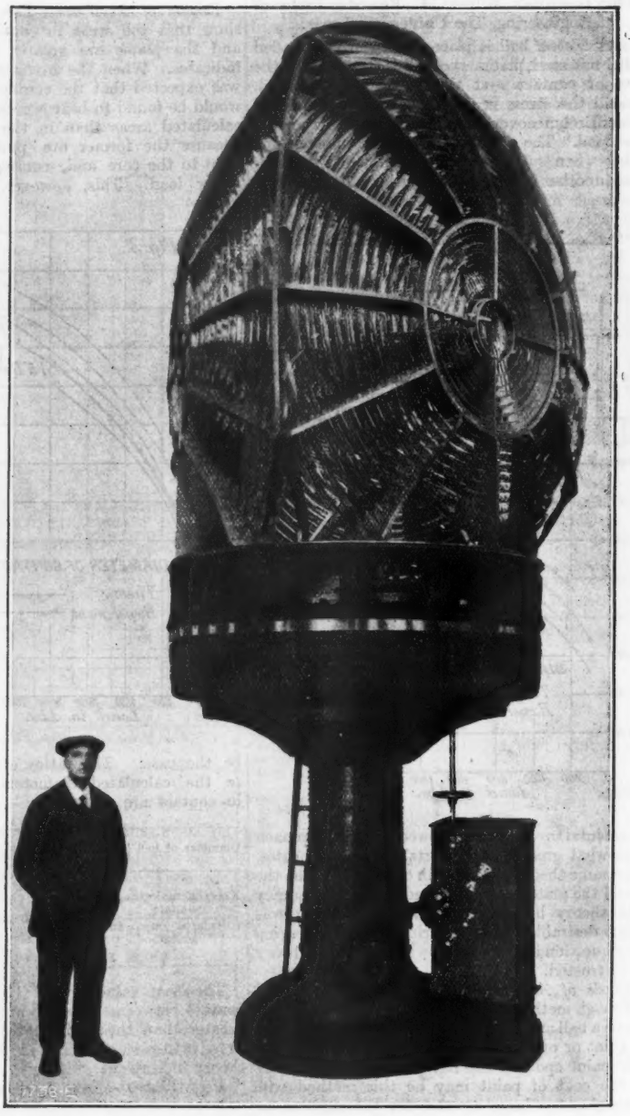


Fig. 2.

Figs. 1 and 2. Optical Apparatus on Standard.

comes the first order light with a 110 mm. mantle giving 3,010 candle-power, with an oil consumption of 3 pints per hour. A light of this order which has recently been installed at Port Said by Messrs. Chance Brothers and Co., Limited, the well-known glass-makers and lighthouse engineers, of Birmingham is illustrated on the present and opposite pages. The light replaces one of an obsolete pattern, and is situated on the top of the old tower at the entrance to the harbour. The optical apparatus is well shown in Figs. 1 and 2 above. It is composed of three panels of refractors and reflecting prisms, each panel embracing a horizontal angle of 120 deg. The whole system is rotated by clockwork at the rate of 2 r.p.m., and every 10 seconds it gives a flash of 0·56 second duration as the beams sweep round.

The apparatus illustrated in Figs. 1 and 2 is shown in position on the lantern in Fig. 3, page 135. The optical portion is supported on an openwork carriage, below which, and attached to it, is a U-shaped cast-iron ring which is supported by mercury contained in a similar but slightly larger U-shaped annular trough. A space of about $\frac{1}{8}$ in. between the float and the trough is allowed for the mercury. The floating apparatus weighs about 3·75 tons, and this is supported by about 450 lb. of mercury. The effect of floating the light on mercury is practically to eliminate all friction, so that the revolving part can be set in motion by the pressure of a finger and driven easily by clockwork in its daily work. The mercury trough is supported by a table which can be raised or lowered by means of a large screw-thread cut on the upper part of the column on which it is carried, as shown in Figs. 1 and 2. This arrangement enables the trough to be lowered for cleaning the mercury, ball-bearing rollers taking the weight of the revolving part when this is being done. Lateral guidance is obtained by horizontal rollers, which prevent the float from touching the sides of the trough. The service table on which the man stands when manipulating the lamp is fixed, while the optical part rotates around him.

The clockwork mechanism shown at the side of the light in Figs. 1 and 2 is driven by a falling weight which can be seen in Fig. 3. The weight required to drive the clock is 980 lb., this being suspended by a wire rope looped round blocks to give a speed reduction of 3 to 1. The clock is made to maintain its action when the weight is being wound up, so that the regularity of the flashes is not interfered with. A centrifugal governor is fitted to regulate the speed of the optic. The clock, like all the rest of the apparatus, is constructed throughout by Messrs. Chance Brothers, and equally with the rest is most beautifully finished. It is an example of the finest English hand-made horological work, every detail being finished and adjusted by skilled craftsmen to a degree of perfection which is almost unknown in these days of mass-production. The driving weight falls at the rate of 6·67 ft. per hour, and it can be raised through its travel of 10 ft. 1 in., in 2·8 minutes with a force of 12 lb. on the driving handle.

The lantern, inside which the optical apparatus is erected, is shown in Fig. 8, page 136, as it appeared

# NEW HARBOUR LIGHT FOR PORT SAID.

CONSTRUCTED BY MESSRS. CHANCE BROTHERS AND CO., LIMITED, ENGINEERS, BIRMINGHAM.

Fig. 4 . SECTION THROUGH FOCAL PLANE.
3 PANELS OF 120°
APPARATUS ONE SINGLE FLASH EVERY 10 SECS.




Fig. 3.

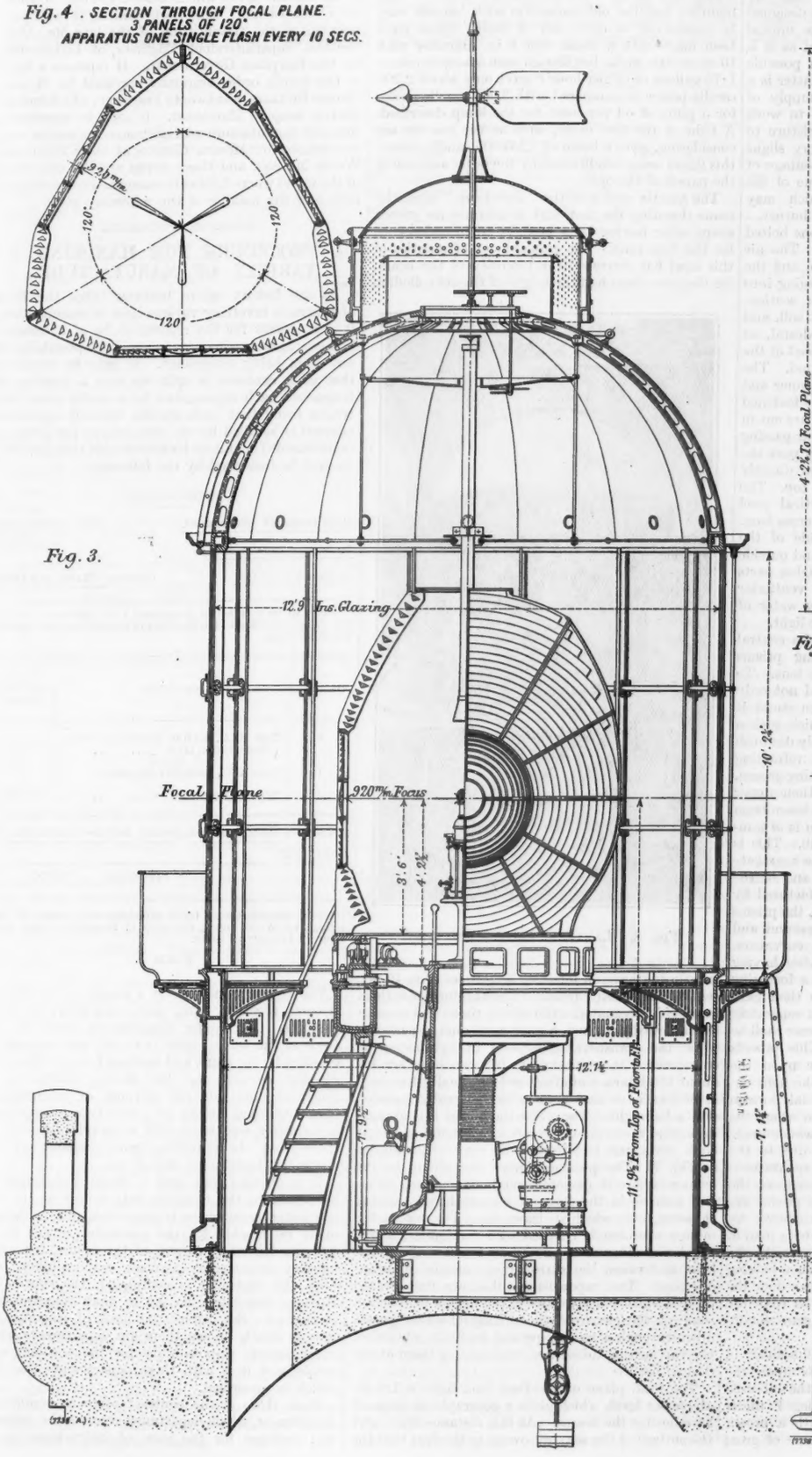



Fig. 5.

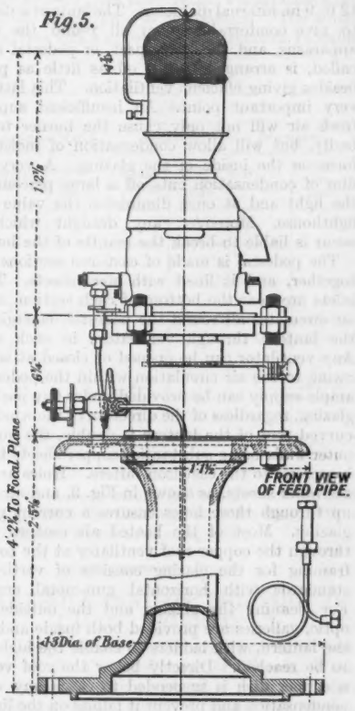



Fig. 6. BURNER REMOVED

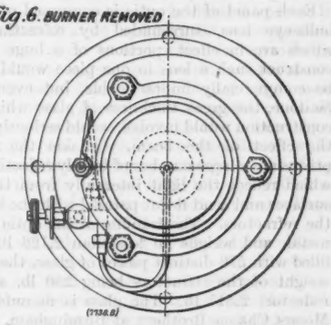
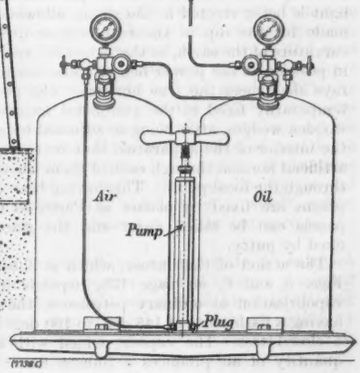



Fig. 7.



when assembled in the shops before shipment to Port Said. Access to its interior is gained by a hole in the top of the tower which can be seen in Fig. 3. The glazing is done with curved plate glass $\frac{3}{8}$ in. thick, and covers an area 10 ft. $2\frac{1}{4}$ in. high by 12 ft. 9 in. internal diameter. The lantern is designed to give comfortable room all round the optical apparatus, and the lower part, or pedestal as it is called, is arranged to cut off as little as possible besides giving efficient ventilation. This latter is a very important point. An insufficient supply of fresh air will not only cause the burner to work badly, but will allow condensation of moisture to form on the inside of the glazing. A very slight film of condensation cuts off a large percentage of the light and at once diminishes the value of the lighthouse. Moreover, any draught which may occur is liable to break the mantle of the burner.

The pedestal is made of cast-iron sections bolted together, and is lined with steel sheets. The air inlets are near the bottom of each section, and the air circulates all round the pedestal, emerging into the lantern through ventilators in each section. Any ventilator can be opened or closed at will, and owing to the air circulation within the pedestal, an ample supply can be provided under any part of the glazing, regardless of the direction of the wind. The curved roof of the lantern is double, the inner and outer walls being substantial copper sheets fastened by screws to the cast-iron rafters. Holes are cut in the inner sheets, as shown in Fig. 3, and air passing up through these holes ensures a current past the glazing. Most of the heated air escapes directly through the copper roof ventilator at the top. The framing for the glazing consists of vertical steel standards with horizontal gun-metal cross-bars. For cleaning the glazing and the outside of the optic, galleries are provided both inside and outside the lantern, with ladders to enable the higher parts to be reached. Directly below the roof ventilator a copper dish is suspended to catch any water of condensation and prevent it falling on the light.

Each panel of the optic is composed of a central bulls-eye lens, surrounded by refracting prisms which are in effect, portions of a huge lens. To construct such a lens in one piece would not only be commercially impracticable, but even could it be done, the great thickness of glass which such a construction would involve, would seriously diminish the effect of the beam. Outside the refracting prisms are a large number of totally reflecting prisms, which reflect the light internally from their upper surfaces and send it out parallel with the beam from the refractors. The framing of the optic is of gun-metal, and weighs no less than 2,128 lb. This is filled with 579 distinct pieces of glass, the aggregate weight of the refractors being 280 lb. and of the reflectors 2,517 lb. The glass is manufactured by Messrs. Chance Brothers, at Birmingham, the prisms being cast roughly to form, and then ground and polished to the required angles and curvature. The final polishing is done by hand. After having been tested for correctness of form, in a focussing machine, the prisms are then set up in their gun-metal panels. Each prism has to be set separately in its panel so that the light from the burner shall be accurately directed to the horizon. This process demands great care and patience, for upon the accuracy of the work the efficiency of the light depends in a great measure. An artificial horizon is set up about 320 ft. from the position where the light is being erected in the shops, allowance being made for the dip of the real horizon due to the curvature of the earth, so that when the apparatus is in position at the proper height above sea-level, the rays shall meet the true horizon. The prisms are temporarily fixed in the gun-metal framework by wooden wedges, after being so adjusted by a man in the interior of the apparatus, that he can sight the artificial horizon through each of them when looking through the focal point. This having been done the prisms are fixed by plaster of Paris, so that the panels can be taken apart and the glass finally fixed by putty.

The action of the burner, which is illustrated in Figs. 5 and 6, on page 135, depends upon the vapourisation of ordinary petroleum, the oil used having a flash-point of 145 deg. to 160 deg. F. under a closed test. The vapour, mixed with a proper quantity of air produces a Bunsen flame of great intensity, which raises the mantle to brilliant incandescence. The mantle of the light in question is of 110 mm. diameter and gives a light of about 3,000 candle-power. Such mantles are now superseding the former arrangement of three 55-mm. mantles, and the old concentric wick burners may be considered as quite out of date. These have been made with a flame over 6 in. diameter with 10 concentric wicks, but though such a lamp consume 1·75 gallons of oil per hour it gave only about 2,200 candle-power as compared with 3,000 candle-power for 3 pints of oil per hour for the lamp described. A light of the first order, such as the one we are considering, gives a beam of 1,250,000 candle-power, this figure being conditioned by the order and size of the panels of the optic.

The mantle used is of the "Autoform" type, the name denoting the fact that it assumes its proper shape after having been brought to incandescence for the first time. The employment of mantles of this kind has increased the intensity of the beam, for they are about half the height of the old collodion

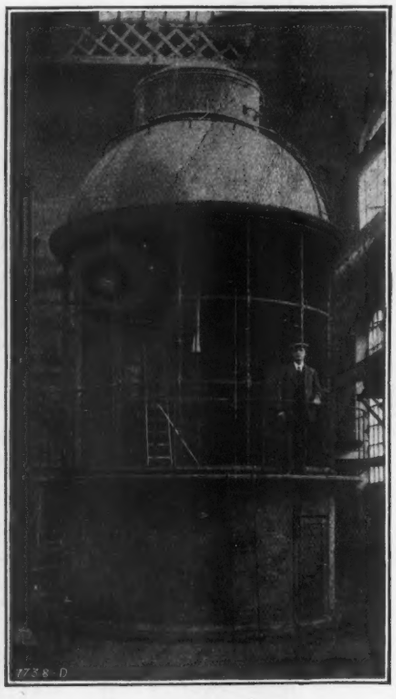


Fig. 8. Lantern, before Shipment.

mantle and have an intrinsic brightness from 40 per cent. to 50 per cent. greater. The autoform mantle is made of impregnated artificial silk tissue and is quite soft and easily packed, a matter of some importance when the transport of objects to lighthouses is considered. It maintains its full candle-power for about 150 hours, and afterwards gradually decreases in brilliance, so that mantles are generally replaced once a fortnight. The oil for the burner is contained in a steel reservoir under an air pressure of about 65 lb. per square inch from an air reservoir, as shown in Fig. 7. The pressure forces the oil up to the burner, where it passes through vapourising tubes and escapes in the form of vapour into a mixing chamber, into which it draws air. The top of the mixing chamber is covered with fine gauze, above which the mixture of oil and air burns with intense heat and raises the surrounding mantle to incandescence. The vapourising tubes are first heated up by a spirit lamp, but when the burner is in action some of the gas from the mixing chamber passes down through a small pipe and burns in jets below the vapourising tubes, thus maintaining them at the desired heat.

The focal plane of the Port Said light is 184 ft. above sea level, which gives a geographical range of 24 miles for the beams. At this distance they meet the surface of the sea, but owing to the fact that the observer on the deck of a ship is above sea level, some portion of the beam is visible at very much greater distances when the air is clear. The light will thus form a striking landmark, and add one more to the famous lights which Messrs. Chance Brothers have constructed. The Port Said light was constructed to the specification of the late Mr. Alex. Grafton, Superintendent Engineer of Lighthouses for the Egyptian Government. It replaces a light of the fourth order originally supplied by Messrs. Chance Brothers over twenty years ago, which had an electric lamp as illuminant. It may be mentioned that the manufacture of lighthouse apparatus was commenced by Messrs. Chance at their Spon-lane Works in 1850, and these works are the only ones in the world where lights are manufactured complete including the making of the necessary glass.

## A PROCEDURE FOR HANDLING A VARIETY OF MANUFACTURE.

In the factory where business takes the form of contracts involving various lines of manufacture, it is necessary for the records to be of a comprehensive character, in order to avoid the possibility of any item being overlooked. It may be observed that each contract is split up into a number of fragments, each represented by a works order, the reason being that each specific type of apparatus covered is handled by the department (or group of departments) definitely identified with that product, as may be instanced by the following:

REQUISITION.

*From* Contract Department. *Date* July 26, 1922.

*To* Works Department.

*Contract No.* 142,622. *Customer* Blank and Cross.

Goods to be supplied in accordance with particulars set out below, and according to specifications in the hands of the engineering department.

| Quantity. | Particulars. | Manufacturing Orders. |
|---|---|---|
| 1 | Type D.Z., 25-h.p. Induction Motor, Specification 1119 .. .. .. | 474 |
| 1 | Type X.Y., Controller (standard) .. | 475 |
| 1 | Type S., Resistance .. .. .. | 476 |

*Delivery*: 5 weeks, in accordance with Delivery Schedule No. 21, dated 1/7/22.

*Issued by* K.P.S.

Note.—Manufacturing Order Numbers are entered in last column by Works Office, one copy of Requisition then being returned to Contract Office.

Form 1.

The contract may cover a number of induction motors, together with, say, controllers and resistances. The feeder departments cater for the needs of the whole; that is to say, raw material is supplied by the store, and castings from the foundry, whether required for the motor, controller, or resistance, but for the purpose of manufacture (*i.e.*, machining, fitting, &c.) each type of apparatus is definitely associated with a specific department, there being the induction motor department, the controller department, and so on.

It is obvious that each of these departments is interested in the contract only so far as its own particular manufacture is concerned, and the department responsible for the controller is not at all interested in the progress of the motor, for which another department assumes responsibility, and once the controller is completed, the contract is likewise completed, so far as that department is concerned. But whilst the limit of responsibility here is clearly shown there are departments which must assume responsibility for the contract as a whole, and it is with these departments that this article is concerned.

First there is the contract office or commercial department, which department receives the contract, and arranges for the issue of instructions to the

works, this being done through the medium of the engineering and drawing departments. Here, however, it is known that for manufacturing purposes, the contract must be split up into clearly defined portions, and arrangements must be made accordingly. If the contract embraces but a comparatively small variety of manufacture, as, for example, an induction motor, with controller and resistance, the whole may be covered by one requisition, as illustrated by Form 1, this being sent to the works office in the first instance, for the necessary manufacturing order numbers to be added. If, on the other hand, the contract is of some magnitude, it may be necessary for a number of requisitions to be issued, and in this case the identification of each requisition with the specific contract is by means of the contract number, which appears upon the requisition.

To enable the contract office to be conversant with the progress made on any contract, a card, similar to Form 3, will be of great assistance. This card is filed alphabetically under the name of the contract, and gives, in addition to the contract number, the whole of the manufacturing order numbers allotted. The requisition does not contain these numbers when sent to the works office, as it is here that the allotment is made, and when this is done, a copy of the requisition bearing the numbers is returned to the contract office.

Whilst in some cases it is necessary for the whole of the contract to be completed before anything can be despatched, other contracts will permit of "part shipments" being made, thus when certain of the units covered by the contract are not closely associated, or when the installation is of a protracted character, as in the case of generating plant, &c. As each manufacturing department completes that portion of the contract in which it is interested, the assembled units covered are received into the commercial store, accompanied by a delivery note as illustrated by Form 4. A copy of this note is subsequently forwarded to the contract office, and this enables the people responsible to enter particulars upon the record card (Form 3) and also to make arrangements for the continued storage or the despatch of the units in question.

The other department interested in the contract as a whole is the Works Department, which in this instance may be divided into two sections, viz., Costing and Production. The costing side may be disposed of lightly, for a copy of the requisition bearing the manufacturing order numbers involved will be sufficient to enable the necessary records to be compiled. The production side, on the other hand, is more complex, in the sense of having to control actual manufacture, and the progress department, in particular, must have a comprehensive record which will show at a glance the outstanding units associated with any contract.

Such a record is illustrated by Form 2, and is in the form of a chart which shows, not only the manufacturing orders associated with any contract, and the number uncompleted at any specific time, but also the total number of contracts, and the aggregate number of works orders in any one department. For example, one column is set apart for the department responsible for the manufacture of induction motors, and every order covering this type of apparatus is entered in this column, whilst upon the same line, but in different columns will be found entries of all associated manufactures, and the number of the contract for which the whole are intended.

Whilst the card record, as illustrated by Form 3, is quite an efficient record for the contract office, practical experience shows that the contract chart is the better adaption for the progress department. The former gives all necessary particulars relating to any one contract, and this is all that the contract office demands, but the progress man, in handling the work associated with one contract, must take into consideration the claims of other contracts outstanding. When giving departmental delivery dates, he is influenced by two factors, viz.: (1) The predetermined completion date of the contract (or definite part thereof) and (2) the amount of work already in each of the manufacturing departments interested. The chart illustrated, whilst not giving all details, is nevertheless a reliable guide, for it shows at a glance whether any of the departments concerned are already overloaded, or whether further commitments can be readily undertaken.

As in the case of the record in the contract office, the delivery note gives information which enables the completion of any unit to be recorded. The whole forms a very efficient record, and renders valuable assistance to those to whom the contract as a whole is entrusted, whilst the time necessary for compilation and adjustment is practically negligible.

CONTRACT CHART.

| Customer. | Contract Number. | Date Received. | Date Due. | 1. Generator. | | 2. Alternator. | | 3. Switchboard. | | 4. Switches. | | 5. Induction Motor. | | 6. Controller. | | 7. Resistance. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Works Order. | Date Complete. | Works Order. | Date Complete. | Works Order. | Date Complete. | Works Order. | Date Complete. | Works Order. | Date Complete. | Works Order. | Date Complete. | Works Order. | Date Complete. |
| Brown and Co. .. | 100,522 | 5/6/22 | 5/9/22 | 273 | | 274 | | | | | | | | | | | |
| Ardle and Binks .. | 111,622 | 16/6/22 | 10/9/22 | | | | | 297 | | 298 | | | | | | | |
| T. B. Jones .. .. | 120,922 | 9/7/22 | 16/8/22 | | | 306 | | | | | | 307 | 26/7/22 | | | | |
| M. S. C. Co., Ltd. .. | 131,822 | 18/7/22 | 10/10/22 | 310 | | | | 312 | | 313 | 31/7/22 | 311 | | | | | |
| Blank and Cross .. | 142,622 | 26/7/22 | 30/8/22 | | | | | | | | | 474 | | 475 | | 476 | 31/7/22 |
| Frames, Ltd. .. .. | 153,122 | 31/7/22 | 9/10/22 | | | | | 523 | | 524 | | 520 | | 521 | | 522 | |

FORM 2.

*Name* BLANE AND CROSS, LTD. *Contract No.* 142,622.

*Date Issued* July 26, 1922. *Due for Completion* August 30.

| Manufacturing Order Number. | Type and Class of Apparatus. | Available for Despatch. | Despatched |
|---|---|---|---|
| 474 | 1 Type D.Z., 25-h.p., Induction motor, Spec. 1119 .. .. | | |
| 475 | 1 Type X. Y., Controller (Std.) .. .. | | |
| 476 | 1 Type S., Resistance.. | | |
| | | | |
| | | | |

FORM 3.

GOODS FOR DESPATCH. *No.* _____

Please receive the undermentioned Parts, completed in accordance with Specification.

*Contract No.* _____ *Manufacturing Order No.* _____

*Customer* _____ *Date* _____

| Quantity. | Particulars. |
|---|---|
| | |

*Manufactured by* | *Inspected by* | *Tested by*

*Received by* _____

FORM 4.

## THE IMPROVEMENT OF THE PORT OF LAGOS, NIGERIA.

LAGOS is the seat of Government and chief port of entry of the Crown Colony of Nigeria, West Africa. It lies at the mouth of a very extensive lagoon system which, with the connecting creeks, constitutes an exceptionally favourable means for inland communication and for the conveyance of goods and produce to and from the surrounding country. These lagoons and creeks are for a considerable distance inland navigable for large canoes and bring down a great volume of water, especially in the rainy seasons. Lagos is also served by a railway, 3-ft. 6-in. gauge, the construction of which was begun in 1896 and progressively extended up-country. By the end of 1911 through rail communication had been established between Lagos and Kano, a distance of 705 miles.

Lagos is the only harbour on about 1,500 miles of coast, the nearest to the west being Freetown, Sierra Leone, and to the east, Forcados River, distant about 130 miles. Until, however, the works described below had been under construction for some years, the port was not available for large ocean-going vessels in consequence of the shallowness of its entrance, which was encumbered with a dangerous and shifting bar. Prior to 1916 all cargo had to be conveyed over the bar in "branch" boats, the transhipment taking place either in the open roads outside Lagos Harbour by means of surf boats or in Forcados River.

The prevailing winds on this part of the coast are from the south-west, the ocean current setting also from the west and running parallel with the shore. The combination of wind and current, almost constantly from the same quarter, causes an incessant and usually heavy swell along the coast, which breaks in violent surf on the shore and sand banks flanking the entrance. The waves are not of exceptional height and the greatest difficulty in crossing the bar arose from the confusing cross seas which occurred in rough weather, constant alterations being caused in the configuration of, and depth over, the bar proper. Considerable fluctuations have also been effected in the coast line by sea and current action. The tidal range is small, spring tides rising only about 3 ft. at the entrance to the harbour.

While it remained in a natural state the entrance was subject to a regular cycle of changes produced by the physical conditions of swell, littoral drift, and fresh water discharge, all of which are liable to appreciable seasonal and annual variations. The complete cycle covered a period of years and,

generally speaking, comprised the gradual forcing of the deep-water channel over to leeward by the action of the swell and the deposit on the windward side of the entrance of the littoral drift of sand from the west. On the occurrence of a pronounced leeward trend of the channel combined with a fresh-water discharge of sufficient volume, the windward spit would be breached and the cycle completed.

Although frequently under consideration from 1892 onwards, it was not until 1906, Sir Walter Egerton being the Governor, that authority was given for a commencement of the works for the improvement of the entrance so as to permit ocean-going vessels to enter the harbour, the direction of the work being entrusted to the firm of Messrs. Coode, Son and Matthews (now Messrs. Coode, Fitzmaurice, Wilson and Mitchell). These works have recently been brought to a successful temporary termination, and a description of their main features will be of interest. The works, as illustrated in Fig. 1 annexed, comprised the construction of two moles and a training bank to secure the sand banks flanking the entrance and enable the currents to be utilised, in conjunction with dredging, in creating and maintaining a deep-water channel on the correct alignment. A commencement was made in the middle of 1908 with the East Mole, which was carried seaward for a length of 5,900 ft. before the West, or windward, Mole was begun in 1912. Construction ceased on the East Mole in 1914, when it had reached the length shown in the sketch. Work on the West Mole continued until the middle of 1922, at which date a length of 5,175 ft. had been completed. The Training Bank, the object of which was to direct the channel into its most effective position for the escape seawards of the outgoing waters, was begun in 1915 and continued until the middle of 1922.

The five comparative charts herewith, together with the general plan of the harbour, illustrate the entrance in 1903 before the works were begun, and at different stages subsequently up to the middle of 1922. An impression of the entrance in 1909, soon after the works were commenced, may also be gained from the view reproduced in Fig. 10, on page 146.

With the assistance of the suction dredgers which have been employed since 1907, the works so far as they have gone have been attended with entirely satisfactory results. From 1877 until 1908 the official draught permitted for steamers crossing the bar varied between the limits of 9 ft. and 13 ft. Subject to one or two minor and temporary set-backs, a progressive improvement has since taken place and from 1916 the mail boats from England have entered the harbour regularly. Since 1917 the permissible draught for vessels navigating the entrance has never fallen below 20 ft., and for the past year this draught has been 21 ft. The minimum actual depth in the entrance channel at low water is now about 25 ft. The five charts given in Figs. 2 to 6 annexed are interesting as they show clearly the effect of the induced scour on the channel as the works progressed.

Fig. 2 illustrates the conditions—by no means at their worst—in 1903, while the entrance was still in a natural state and subject to very material alterations even in the space of a day. Fig. 3 gives the position at the end of 1912, when the East Mole had been projected a distance of some 6,500 ft. and a short length of the West Mole had been built. This completed length of the East Mole, by preventing the lateral escape eastward of the ebb current through the pre-existing swashways on that flank of the entrance and by guiding the flow in a more definite direction towards open water, had already caused a distinct improvement in the navigable conditions. The next chart, Fig. 4, shows further progress on both moles and the beginning of the West Training Bank. As the West Mole progressed between 1912 and 1915 it tended to cut off the action of the ocean swell and littoral drift from the west in forcing the channel over to leeward, and the protection thus afforded resulted in a more westerly trend being given to the inner portion of the entrance channel. The West Training Bank was designed to correct any undue tendency in this direction. Figs. 5, 6 and 1 show the gradual deepening of the channel as the works progressed. The latest plan, Fig. 1, also shows how the increased shelter derived from the West Mole and the effect of the West Training Bank have improved the position of the channel.

To quote from a report, dated April 9, 1919, by Sir Frederick Lugard, the predecessor of the present Governor, Sir Hugh Clifford: "The work has been attended with unqualified and progressive success. . . Branch boats have for some time ceased to ply . . . The cost (*i.e.*, for cargo) inwards and outwards under the branch boat system was calculated to be not less than 10*s.* per ton. This is now replaced by harbour dues calculated on a basis of 4*s.* per ton . . . The benefit to trade has been enormous, not merely in diminution of shipping costs, but

*Fig. 1.* GENERAL PLAN OF LAGOS HARBOUR JUNE 1922.

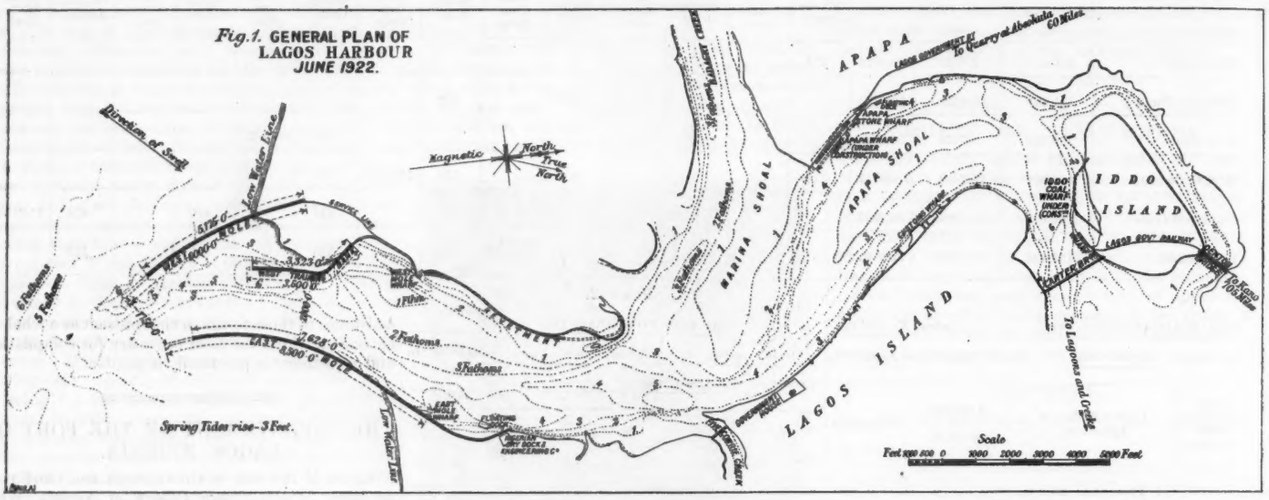



*Fig. 2.* IN 1903.

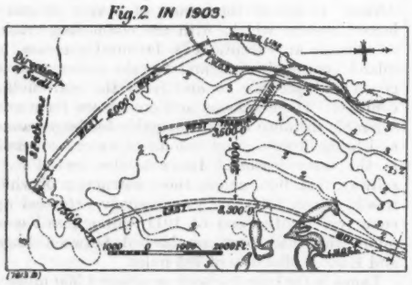


*Fig. 3.* AT END OF 1912.

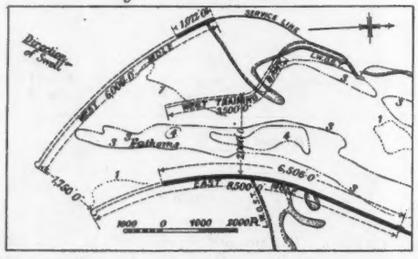


*Fig. 4.* AT END OF 1915.

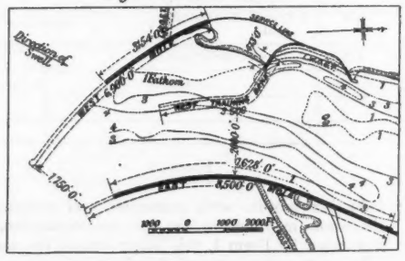


*Fig. 5.* AT END OF 1918.

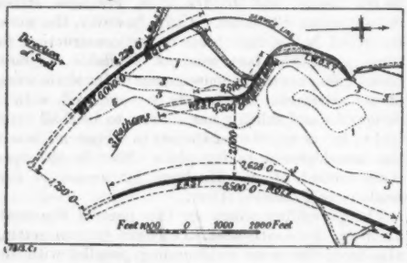


*Fig. 6.* AT END OF 1920.

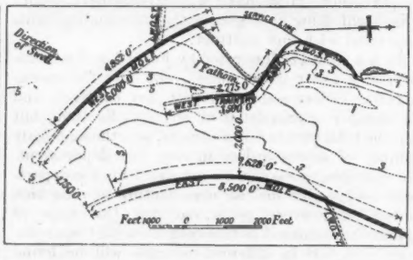
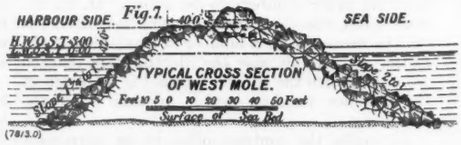


*Fig. 7.*



also in saving of time, breakages, and losses in transhipment, &c."

The moles and training bank are of the rubble mound type as illustrated in Fig. 7, and suitable stone (granite) for their construction was obtained from Abeokuta some 60 miles away and situated on the Government Railway. A quarry was opened out and equipped with the requisite pneumatic rock-drilling plant, cranes, &c. The stone was loaded into skips of 8-tons capacity which were placed on special wagons for conveyance over the railway to the terminus at Apapa, on the western margin of the harbour, about 4 miles from the site of the entrance works. On arrival at Apapa the loaded skips were lifted from the wagons and placed on board the barges lying alongside the terminal wharf. These barges were towed down the harbour to the small wharves which have been erected on either side of the entrance, where the skips were lifted out of the barges, placed on wagons and run out to the ends of the works. Here further cranes were stationed to lift the skips and tip

*Fig. 8. CROSS SECTION OF WHARFAGE AT APAPA.*

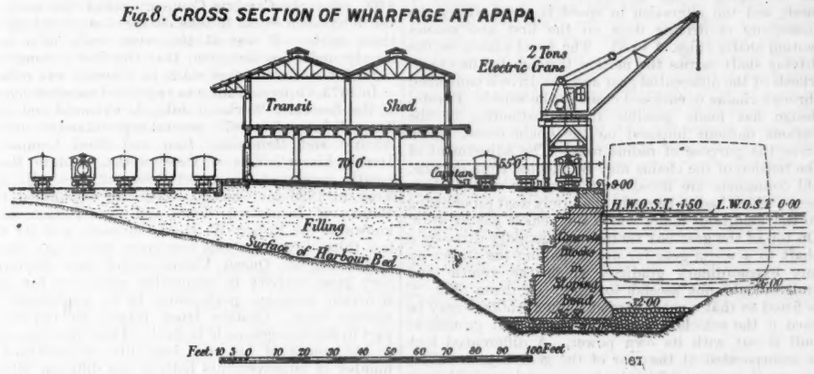
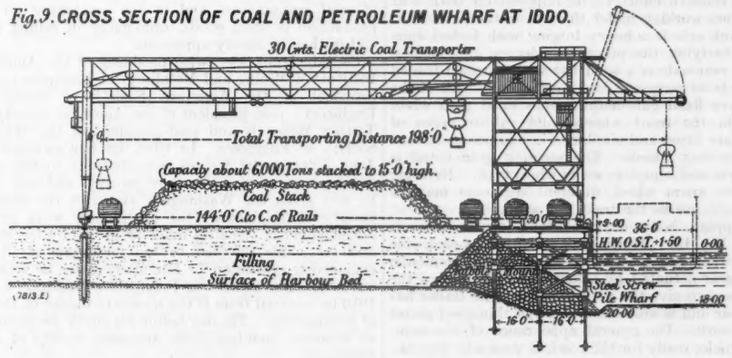



*Fig. 9. CROSS SECTION OF COAL AND PETROLEUM WHARF AT IDDO.*




their contents. A large number of lumps of stone up to a maximum weight of 12 tons were also supplied from the quarry for the coating of the weather slopes of the moles, more especially on the windward side of the West Mole. Owing to its exposed position the surface of this latter work was raised to 12 ft. above the level of low water as compared with 9 ft. and 7 ft. in the case of the East Mole and West Training Bank, respectively. Moreover, a parapet of large lumps of stone was deposited on the weather side of the West Mole, as construction progressed (as can be seen in Fig. 12, page 146) to form an automatic supply of suitably-sized material to counteract any tendency to breach the exposed slope of the work during rough weather. This parapet was replenished as occasion arose.

With the works in full swing the quarry output reached a total of 140,000 tons to 180,000 tons per annum, and to the middle of 1922, when the works were temporarily stopped as having for the time being satisfactorily achieved their object, over 1,780,000 tons of stone had been deposited. A view of the quarry in the early stages of the work is given in Fig. 11, page 146, one of the large skips loaded on a truck being shown in the foreground.

Although considerable quantities of overburden had to be removed from the quarry surface, the conditions in this respect were not unduly onerous. The stone was, of course, produced in a large variety of sizes, but from the nature of the permanent works and incidental demands it was practicable usefully to consume the whole output. The following table shows approximately the relative proportions of the different sizes in which the stone was produced in quarrying :—

| | Percentage of Total Output. |
|---|---|
| Lumps of 5 tons and upwards ... | 6 |
| Lumps of 1 ton to 5 tons ... ... | 33 |
| Lumps of 1 cwt. to 1 ton ... ... | 24 |
| "One-man" rubble, ¼ cwt. to 1 cwt. | 16 |
| Smaller rubble and refuse ... ... | 21 |

Between four and eight pneumatic drills were kept employed, the average depth of hole being from 10 ft. to 12 ft. There were eight 5-ton and two 12-ton steam locomotive cranes. The rolling-stock, apart from locomotives, consisted of 176 wagons, each carrying one skip and 70 bogie-wagons each holding three skips. The labour employed at the quarry averaged 300 free men and 50 convicts. The output was as follows :—

| | Tons. |
|---|---|
| Annual output of stone per working drill ... ... ... | 30,000–40,000 |
| Annual output of stone per working crane ... ... | 25,000–35,000 |
| Annual output of stone per man | 400–500 |

| | Per 1,000 Tons of Stone |
|---|---|
| Consumption of gelignite ... | 130–140 lb. |
| Consumption of fuse ... ... | 275–375 lin. ft. |
| Consumption of detonators ... | 50–70 No. |

The gross cost per ton of the stone deposited in the works to the end of June, 1922, was 13*s.* 8*d.*, made up as follows :—

| | Per Ton. *s.* | *d.* |
|---|---|---|
| Quarrying and loading, including maintenance of railway stone wagons ... | 2 | 8 |
| Railway freight (60 miles) ... ... | 5 | 0 |
| Cranage at railway terminal ... ... | 0 | 3 |
| Towing and barging ... ... ... | 0 | 9 |
| Unloading, running out and tipping... | 1 | 9 |
| | 10 | 5 |
| Capital charges for plant, &c., including railway stone wagons ... ... | 3 | 3 |
| | 13 | 8 |

In addition to the above-named quarry and railway plant seven 12-ton cranes, a tug, nine 80-ton barges, two locomotives and five hundred and fourteen 8-ton skips were employed on the works.

It is intended in due course to consider whether it would be advantageous further to extend the two moles and training bank to their designed terminations as shown in Fig. 1 by dotted lines, but in the meantime the works with a continuance of dredging operations should result in creating some increased depth in the entrance, and the permanent works may be confidently predicted to conserve any such increase.

Consequent on the successful results which have attended the execution of the entrance works, the development of wharfage and other facilities is now in active prosecution inside the harbour. The trade of the port may be divided into two main categories : (*a*) The rail-borne traffic, inwards and outwards, and (*b*) the water-borne lagoon and creek trade.

For the former class of traffic wharfage accommodation is now under construction at Apapa, indicated on the accompanying plan of the harbour, which in future will be the main terminus of the Government Railway. The facilities comprise the construction of a wharf wall 1,800 ft. in length, designed for an ultimate depth alongside of 32 ft. below low water, 26 ft. only being dredged in the first instance, the erection of four double-storey transit sheds behind the berthage, each 340 ft. in length by 70 ft. in width, with the installation of the requisite cranes and other equipment. The wharf is being constructed of concrete blockwork, set in sloping bond on a foundation of granite rubble, as outlined in the cross-section, Fig. 8, and the transit sheds will be of reinforced concrete with steel roof trusses.

The water-borne trade is at present dealt with on the Lagos Island side of the harbour, where the berthage for ocean-going steamers is limited to the length of 1,180 ft. of the Customs Wharf, which can accommodate vessels up to a maximum draught of 21 ft. The berthage at the Customs Wharf is practically confined to import traffic, exports being dealt with by means of lighterage from the various small privately-owned jetties dotted along the harbour margin of Lagos Island to the ocean-steamers lying in the stream.

For the convenient discharge of coal, imported into Lagos from the Udi coalfields, situated about 130 miles from Port Harcourt up the Eastern Railway of Nigeria, for consumption by the Government Railway, dredgers and other craft, and for other purposes, a wharf, 720 ft. in length, is being constructed at the upper end of the harbour on Iddo Island, which for many years has been the terminus of the railway, but which for general rail-borne traffic purposes will, on completion of the Apapa wharfage above mentioned, be supplanted by this latter site. The Iddo Coal Wharf is being constructed on steel screw piles, as shown in Fig. 9, annexed, with a granite rubble bank beneath to retain the filling with which a large area is being reclaimed behind. This wharf is being equipped with two unloading transporters, each capable of discharging coal at the rate of 60 tons per hour, either direct into railway wagons or into stack, for which a capacity of 6,000 tons has been arranged within the span of the transporters. The down-stream portion of this wharf will be employed for the discharge of kerosene.

The Government Marine Department's dockyard and shops are situated at Apapa immediately up-stream of the wharfage now under construction. Here the dredgers and other Government craft are based and kept in repair, the equipment including two small floating docks, each of 400 tons lifting capacity. The fleet of dredging vessels includes four suction dredgers, two of 1,800 tons, one of 1,200 tons, and one of 600 tons hopper capacity, all four having 27-in. pumps. Two of these dredgers are, however, fourteen years old. The Nigerian Dry Dock and Engineering Company also provides repair facilities in the harbour and possesses a floating dock with a lifting capacity of some 1,800 tons.

The entrance works, Iddo Coal Wharf, and Apapa Wharfage have been designed for the Government of Nigeria by Messrs. Coode, Fitzmaurice, Wilson and Mitchell, of 9, Victoria-street, Westminster, the successors of Messrs. Coode, Son and Matthews, the two former works being constructed departmentally under their technical supervision. A contract was let by the Crown Agents for the

Colonies in the middle of 1921 to Sir W. G. Armstrong, Whitworth and Co. for the construction of the Apapa Wharfage, and this work should be completed towards the end of next year.

## 6-TON MOTOR VEHICLE FOR SERVICE AT HIGH ALTITUDES.

The field of service of the motor vehicle is continuously increasing. Each new application presents new problems, but the designers have shown considerable resource in meeting the special demands of the exceptional circumstances of working. A vehicle for use under trying conditions which has, in consequence, many features of interest, is illustrated in Figs. 1 to 14, on Plate XII. This motor was designed and constructed by Messrs. Halley's Industrial Motors, Limited, of Yoker, Glasgow, for use at the tin mines of Bolivia. In the course of its ordinary duty it has to work at altitudes of from 11,000 ft. to 15,800 ft. above sea level. At the highest point the atmospheric pressure is only 8·3 lb. per square inch and consequently the power obtainable from the available cylinder capacity is greatly reduced. Unfortunately where the air pressure is low an ample reserve of power is essential because of the gradients to be encountered. Reliability on a service of this type is of course imperative, as the vehicle must travel through regions where facilities for effecting repairs are not available. Another condition imposed upon the designer of this motor was that the engine must run on petrol or paraffin, as the arrival of supplies of petrol at regular intervals cannot be relied upon.

The chassis is illustrated on Figs. 1, 2 and 3, on the Plate. It has a frame made of plain rolled steel channel section, 6 in. by 3 in., connected by cross-members with riveted gussets. As the motor has to serve not only for the carrying of the load on the chassis but also for the drawing of a 3-ton to 5-ton trailer a special member has been incorporated in the design at the rear of the frame to carry the trailer drawbar pin. The gear-box is shown in a series of views, Figs. 4 to 8, on the Plate, and the engine by four illustrations, Figs. 9 to 12.

The engine has six cylinders of 5 in. bore and 6½ in. stroke, which gives a Treasury rating of 60 h.p. and the normal speed of running is 1,000 r.p.m. The cast-iron cylinders are of the L-head type and with two cylinders in each block. Detachable heads have been introduced to facilitate access to the pistons and valves for decarbonising and to permit the increase of the compression ratio when in use at the high altitudes. For running at normal atmospheric pressure on paraffin, a compression ratio of 3·9 has been provided, but this is to be raised to 4·9 when the motor reaches its normal field of service. Considerations of effective and efficient combustion have dictated the form of the combustion chamber. The valves, which are of the orthodox type made of 3 per cent. nickel steel, work on slightly inclined seats. Roller tappets have been introduced for the operation of the valves. The pistons are made of cast-iron and provided with recesses for two rings at the top and with cut scraper passages in the skirt to prevent the passage of oil into the cylinder heads. The gudgeon pin is secured in each piston by means of slots cut in the ends, fitted to which is a locking ring within a groove in the piston. At the gudgeon-pin end of the connecting rod a phosphor bronze bush is supplied while the big-end has four bolts and is provided with a gun-metal shell lined with white metal. The aluminium crank-case is very deep, and to obtain rigidity and reduce vibration the crankshaft is situated within the top part and not at the line of junction with the bottom. The lower part is thus very shallow, but is provided with sumps for the lubrication of the big-ends of the connecting rods. Four main bearings of gun-metal with white metal linings support the crankshaft and the aluminium caps are reinforced with thick steel plates. Oil rings at the ends of crank-case prevent the escape of the oil. The camshaft for the operation of all the valves is supported in four bearings and may be moved in the line of its length to bring a set of half-compression cams into action to make easy starting possible. The camshaft driving wheel is provided with a special form of brake to eliminate torsional vibration in the camshaft. Another important feature is that the timing wheels are doubly supported in the crank-case and front cover to prevent the occurrence of the troubles due to overhung bearings. A ball governor (Fig. 11) is driven by a spiral wheel from the camshaft, and limits the speed of running to 1,000 r.p.m., by means of a butterfly throttle valve in the main induction pipe. On an extension of the governor driving spindle the oil pump is mounted. It lies in the sump in the deep part of the crank-case, and is of the gear type. After passing through a filter the oil is distributed to the bearings and the troughs below the connecting rod big-ends. The ignition system consists of a Simms' magneto with an impulse starter. It is driven through two vernier rubber couplings, so that easy adjustment of the timing may be effected without, in any way, disturbing the timing wheels in the crank-case.

The fuel tanks are placed below the driver's seat. That for paraffin is of 25 gallons capacity, while one of 16 gallons serves for petrol. The induction system was designed to make the use of either fuel possible and, to obviate every chance of trouble, the whole system is duplicated. As the mixture controls are connected to the dashboard and two accelerator pedals are fitted, the change from one type of fuel to the other may be readily and quickly accomplished at any time. Exhaust heating is used to assist the vaporisation of the paraffin. The centrifugal pump for the cooling water for the jackets is driven from the timing gears of the engine and the usual fan arrangement to assist the air draught through the radiator is provided.

The clutch is of the single plate type with fabric discs and is run dry. Multiple levers from the pedal to the rear driving plate reduce the pressure necessary on the pedal and the coil springs are easily got at for adjustment. Between the clutch and the gear-box the fabric disc type of universal joint is used.

There are four speeds forward and one reverse. All the wheels for the various speeds are constantly in mesh, and the alteration in speed is obtained by the enmeshing of driving dogs on the first and second motion shafts (Figs. 4 to 8). The bevel pinion on the driving shaft carries the motion through to the crown wheels of the differential gear and the drive is continued through chains in enclosed cases to the wheels. Careful design has made possible the withstanding of the various motions imposed on the chain cases, which serve the purpose of radius rods. The adjustment of the tension of the chains may be effected from outside. Oil containers are fitted on the outside of the chain cases, which had to be made absolutely dust proof owing to the conditions under which the vehicle has to work. On top of the gear-box there is an auxiliary drive by a shaft to a worm gear for use in pulling the trailer up any extraordinary gradient which the vehicle and trailer could not ascend together. A drum (Fig. 2) is fitted so that a cable carried to an anchorage may be used if the vehicle becomes bogged in soft ground to pull it out with its own power. A differential lock is incorporated at the rear of the gear box to enable an equal tractive effort to be imposed on both rear wheels when working under those conditions.

The front axle is a heavy forging with forked ends (Fig. 3), carrying the pivots by sleeves and bushes, while the rear axle is a solid bar with journals turned on the ends to carry the cast steel wheels. All of the wheels have fixed gun-metal bushes lined with white metal. On the front wheels solid rubber types of 160 mm. are fitted and similar twin equipment is used for the driving wheels. The steering gear fitted is of the worm and complete worm wheel type. By using a complete worm wheel, different segments may be brought into use as the teeth get worn.

The tipping body of steel tank construction is shown in Fig. 13. Hinge pins are fitted at each side so that either can be used to suit the requirements. A screw gear actuated by a handle at the rear of the body is used to give the requisite lift. The trailer has similar gear and is also constructed of thin steel plates on framework. The general appearance of the completed vehicle, ready for the road, is shown in Fig. 14.

The Danish State Railways.—The financial position of the Danish State Railways shows a marked improvement. The receipts for last financial year have certainly receded some 25,000,000 kronen, as compared with the previous year, of which decrease about one-third concerns the passenger traffic and two-thirds the goods traffic. The expenditure, however, for the same year has decreased about 89,000,000 kronen, from 229,000,000 kronen to 140,000,000 kronen, whilst there was a deficit on the financial year 1921–22 of about 58,000,000 kronen, there is a surplus of 6,000,000 kronen for last year. Allowing 4,500,000 kronen for writings off, there still remains a small balance on the right side. The number of employees has been reduced from 20,339 to 18,970, a saving of 6·7 per cent.

The Institute of Metals.—The volume of Proceedings of this Institute, vol. xxix, which deals with the meeting held in London on March 7 and 8, and gives a large number of abstracts from journals and other publications, is available since the commencement of July; the secretary is to be congratulated upon this "quick work." The book, including the very detailed indexes, covers over 900 pages, more than half of which are taken up by the papers—20 in number—read at the March meeting, and the discussions thereon. In sending us this volume, the secretary says he understands from Dr. Rosenhain, F.R.S., who has recently returned from a three months' lecture tour in the United States, that there is no book issued in America, or in any other part of the world, to compare with the Journal of this Institute; it is regarded very highly by American metallurgists and engineers. The book can be obtained from the offices of the Institute, 36 to 38, Victoria-street, S.W. 1, or from any bookseller; its price is 31s. 6d. net.

## THE LATE CAPTAIN ROBERT WOOLSTON HUNT.

We regret to learn from the American journals of the death, at Chicago, on July 11, of Captain Robert Woolston Hunt, "an outstanding figure in the development of the technique of the steel industry," to quote from *The Iron Age*, New York.

Captain Hunt was born on December 9, 1838, at Fallsington, Bucks County, Pa. He spent several years learning the practical side of iron-making in the rolling mills of John Burnish and Co., Pottsville, Pa., and later took a course in analytical chemistry in the laboratory of Booth, Garrett and Blair, when he entered the Cambria Iron Company, Johnstown, Pa. On August 1, 1860, he established at the Cambria works the first laboratory in the United States as a direct part of an iron or steel organisation. He entered the United States Military Service in the autumn of 1861, and was in command of Camp Curtin, Harrisburg, Pa., with the rank of captain. At the close of the Civil War, he returned with the Cambria Company, and was sent to the works at Wyandotte, Mich., where experiments with the Bessemer process were being conducted. He was placed in charge of these from July, 1865, to May, 1866, when the Cambria Company called him back to the Johnstown works to take charge of steel-making at those works. It was at the same works later and largely under his direction, that the first commercial order for steel rails ever made in America was rolled.

In 1873, Captain Hunt was appointed superintendent of the Bessemer Works of John A. Griswold and Co., Troy, N.Y., and in 1875, general superintendent of the Albany and Rensselaer Iron and Steel Company. During his activities at these works, Captain Hunt greatly developed the use of Bessemer steel. He left Troy in 1888 for Chicago, where he established the Bureau of Inspection, Tests and Consultation, now known as the Robert W. Hunt Company, and for the last thirty-five years this company—which has offices in London, 52, Queen Victoria-street—has displayed very great activity in connection with steel for construction purposes, particularly in its application to railway work. Captain Hunt played an important part in the changes made in steel rail specifications, and in the course of his very busy life he instituted a number of improvements both in the different phases of steel manufacture and in the machinery for the production of steel goods, principally in rolling mills and in their accessory apparatus.

Captain Hunt was twice president of the American Institute of Mining and Metallurgical Engineers; past-president of the American Society of Mechanical Engineers; past-president of the American Society for Testing Materials and past-president of the Western Society of Engineers. In 1912, he was awarded the John Fritz medal for his contributions to the early development of the Bessemer process, and last June he was given the Washington award of the Western Society of Engineers "for his pioneer work in the development of the steel industry in the United States and for a life devoted to the advancement of the engineering profession." For many years he acted as a trustee of the Rensselaer Polytechnic Institute, and in 1916 he received from it the honorary degree of Doctor of Engineering. The day before his death he was made an honorary member of the American Society of Civil Engineers.

Captain Hunt became a member of the Iron and Steel Institute in 1899, and was well known of the members for his practical work in regard to steel manufacture. He delivered the presidential address on the occasion of the joint meeting in London of the Iron and Steel Institute with the American Institute of Mining Engineers; we reported the address at the time. (Engineering, vol. lxxxii, page 112.) In this, he traced the history and development of steel manufacture in the United States, a manufacture in which he played so prominent a part. Captain Hunt was a member of the Institution of Civil Engineers since 1901; and a member of the Institution of Mechanical Engineers since 1898.

We may conclude this short notice by stating that he had the gift of friendship, and his loss will be deplored not only by his numerous close associates, but by all who ever had the pleasure of meeting him.

The Gothenburg Exhibition.—According to official statements the Gothenburg Exhibition bids fair to prove a success generally and also as far as the commercial aspect is concerned. It was not meant to be, and was not framed as a trade fair or exhibition; its main object was to show the world what Sweden's industry had achieved up to the present day. The number of visitors has been unprecedented, and amongst them have been numerous foreign commissions which have come over to see what Sweden could supply. Important deals have already taken place, and it is the general opinion in Sweden that the exhibition will fully answer its purpose and will thus justify the heavy expenditure incurred.

## NOTES ON NEW BOOKS.

The titles of books are fortunately not often so misleading as is the case with "*A Handbook of Testing*," Vol. II, "*The Theory of Prime Movers*," prepared by Professors C. A. Middleton Smith and A. G. Warren, of the University of Hong Kong, and published by Messrs. Constable and Co., Limited, at a price of 22*s.* 6*d.* net. Anyone who purchases this book as a volume on the testing of engines will be disappointed, for it contains little or nothing relating to that subject. It is an expansion of notes on the theory of heat engines, prepared for use in courses of lectures for students. The work is by no means exhaustive even in that field, and the aim of the authors, stated in the preface as being "to produce a book useful to students working for an engineering degree," can only be said to have been accomplished to a limited extent. The standards of requirements of our universities vary considerably, but more than mere theoretical book work is usually expected in the case of students sitting for an examination for a degree in engineering. In the opening chapter on "The Problem of Energy" the authors refer in eulogistic terms to the value of research work, but have not thought it worth while to deal with the deductions and results derived from recent investigations. The work of those who succeeded in wresting "from Nature secrets which would benefit humanity, either materially or in its desire for knowledge," at any rate during the fruitful period of the last twenty years, has been neglected, in the compilation of this volume. This is much to be regretted, as most of our universities and technical colleges show by their degree and diploma examination papers that acquaintance with the most recent research work is expected from students. This book can only be considered as another addition to the many that deal with the common text-book theory only.

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With the third volume, now before us, of the second part on "*Eisenbrückenbau*," the publication of Professor Georg Christoph Mehrtens' "*Vorlesungen über Ingenieur-Wissenschaften*" has probably come to an end. Dr. Mehrtens, professor of engineering at the Technical High School of Dresden, died during the war, and the preface to the present volume bears the name of his daughter, Meta Mehrtens, who prepared the almost completed manuscript of her father's lectures, on iron bridge-construction, for publication with the assistance of several colleagues of her father's, Messrs. Flack, of Frankfurt; Kade, of Sterkrade; and G. Lindenthal, of New York. The delay was largely caused by the desire to supplement the information on bridges (especially American) under construction. As now published the book forms a volume of 425 pages, with 580 illustrations. It is published in Berlin by Wilhelm Engelmann (price 28 Swiss francs). Professor Mehrtens was the author of a memoir on German bridge construction which several large firms prepared for the Paris Exhibition of 1900. What he said on that occasion and later with respect to British bridge builders and their share in international bridge construction, by comparison with the achievements of American, French and German engineers and firms, hardly justified incorporation in the present volume. That critical survey, for which, it will be understood, the war is in no way responsible, was not distinguished by breadth of standpoint, and it would have been better to omit such references and to lay more stress on recent developments, so far as the outbreak of the war enabled the author to deal with progress outside his country. The second volume of the work appeared in 1914.

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The industrial depression of the year 1922 is reflected in the "*VIIth Annual Report of the Society of Chemical Industry on the Progress of Applied Chemistry*" (published by the Society, Central House, Finsbury-square, E.C. 2; price 12*s.* 6*d.* to non-members). Mr. Coleman states in his section on plant and machinery that the year has been poor in new developments of chemical plant and machinery, but steady progress has been made in detail. The interest taken in Fuel problems (Professor J. W. Cobb and Mr. H. J. Hodsman) has revived, and in reviewing gas and destructive distillation, Dr. G. Weyman finds many signs of a recovery. That applies also to non-ferrous metals; but Dr. C. A. Edwards and Mr. H. I. Coe see no indication of a revolution in the process of zinc smelting, though the total annual production of electrolytic zinc is said to exceed 125,000 tons. Mr. F. L. Barrett is glad to acknowledge the good work done by the Textile Research Associations. But Dr. M. W. Travers regrets that the problems of optical glass again fail to attract original workers, and Mr. W. Emery has the same complaint to make about ceramics. The latter considers that the advantages of the osmoses of clay have been over-estimated, and he is not any more impressed than the Berlin Material-prüfungsamt is, with the cold-glazed kerament cement tiles; on the other hand he draws attention to the utilisation, suggested by H. Koppers, of volcanic deposits as bonding materials for silica bricks. In photography the depressed conditions have been little felt, according to Mr. R. E. Crowther. As regards sanitation, Dr. H. T. Calvert reports that activated sludge processes have been adopted at Reading, Sheffield, Stockport, and by a large number of other local authorities, and that the bioflocculation process introduced by Mr. J. D. Watson, at Birmingham, deserves attention; the sewage is left in contact with activated sludge for a short period and is then sprayed over percolating filters. With respect to general features we notice again changes in the contributors to the Report; but the general arrangement of this very useful computation remains unaltered. With its 569 pages this seventh volume is slightly smaller than those of 1921 and 1920, which run into 625 pages; the reduction is partly due to the omission of the section on Explosives.

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A remarkable feat of condensation has been effected by M. Maurice Roy, Ingénieur au Corps des Mines, who, in a little book of some 130 pages, has given the essentials of Prandtl's remarkable mathematical development of Lanchester's theory of aeroplane lift. M. Roy's book bears the title "*Sur la Theorie des Surfaces Portantes*," and it is published by Messrs. Gauthier-Villars et Cie, Paris, at 12 francs net. In accordance with what is a common practice with French scientific writers, the plan adopted is that of proceeding from the general to the particular, whilst British authors generally prefer the converse method of building up the general theory by starting with the simpler cases, and gradually introducing additional complications, as the necessity arises. Both plans have their advantages. The French method leads to conciseness but makes at the outset a greater demand on the mathematical attainments of the reader. Those, however, who have a fair knowledge of the mathematical theory of hydrodynamics will have little difficulty in following M. Roy's demonstrations, and his work will be a great boon to the many English readers whose limited knowledge of German makes it difficult for them to peruse the original papers.

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The series of Technical primers, edited by R. E. Neale, B.Sc., and published at 2*s.* 6*d.* per volume by Sir Isaac Pitman and Sons, Limited, London, is growing continuously and now forms a library of about 70 volumes. The aim in the production of these small books, each of about 120 pages, has been to present in each the essential principles of some sub-division of technical work. Each volume thus gives a handy survey of its subject for those who do not require a specialised treatment. Among the recently issued volumes we notice one on "*Streets, Roads and Pavements*," by H. Gilbert Whyatt, the borough engineer and surveyor of Grimsby, which deals with the materials used in processes of construction, the equipment necessary and the methods adopted. In it there are notes on dust prevention, arterial roads and many matters connected with the construction and upkeep of highways. "*Traction Motor Control*," by A. T. Dover, of the Battersea Polytechnic, gives a very clear exposition of the principles involved in the operation of the propulsion equipment of tramways, trains and electric battery vehicles. W. S. Flight contributes "*Electric Insulation*," in which he discusses the functions and characteristics of insulating materials, their testing and the application of the various types to electrical machinery. "*Industrial Electric Heating*" has been written by J. W. Beauchamp, and in this he has brought together information relating to furnacework, welding, electric heated tools and cooking. The protection of an alternating-current system from the effects of faults has been treated by J. Henderson and C. W. Marshall in a volume, with the title "*A.C. Protective Systems and Gear*." After describing various types of apparatus, the authors consider their application in a general supply scheme and, from their personal experience, make suggestions regarding the complete equipment necessary. A chapter on the testing of the various gears and systems is a valuable part of this useful little book. The author of a primer on "*Electric Cranes and Hauling Machines*," F. E. Chilton, has compiled a great deal of information, treated on broad lines, regarding the methods of operation of a number of the more generally used types of cranes and haulage gears. Each volume is amply illustrated and is completed with a bibliography for the assistance of those who wish further and more special information.

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Among recent additions to the small volumes of the Sammlung Göschen (Berlin and Leipzig: Walter de Gruyt and Co.) offered in this country at 1*s.* each, we notice the "*Aufgaben sammlung zur Festigkeitslehre mit Lösungen*" (Worked-out Problems on the Strengths of Structural Parts) of R. Haren, now prepared in a third revised edition by J. Furtmayr, of Stuttgart, and the "*Walzwerke, Einrichtung und Betreib*" (Rolling Mills, Construction and Working) of A. Holverscheid, of Aachen. What we have said on other occasions to the effect that the authors of these booklets keep to the point and do not waste space in talk or in advertisement applies also to these volumes.

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An extraordinary revolution has been effected during the past thirty years in our views as to the nature of matter and of light. The concept of the electron seems to have been due originally to the late Johnstone Stoney, but it was, of course, J. J. Thomson who first definitely proved that Crookes' intuition had been sound, and that the cathode rays were neither a special form of light, as contemporary German physicists contended, nor were particles of ordinary matter. As for light, thirty years ago the corpuscular theory was completely discredited and the undulatory theory, or rather Maxwell's electromagnetic form of it, held the field without a rival. Since then very definite evidence has been obtained that light possesses some marked corpuscular properties, which are irreconcilable with the undulatory theory, whilst the latter, on the other hand, offers an explanation of certain phenomena with which the corpuscular hypothesis is unable to deal. These striking developments have led to many attempts at the popularisation of the new ideas. In this country the need has been very satisfactorily met by the courses of lectures provided by the Royal Institution. Similar efforts have been made abroad, amongst which may be noted the essays on *The Constitution of Matter* which were contributed to by Professor Max Born to "Die Naturwissenschaften," in 1920. These have now been translated by Messrs. E. W. Blair and T. S. Wheeler, and are published under the stated title by Messrs. Methuen and Co., Limited, at 6*s.* net. The volume covers a wide field and does so very satisfactorily. The structure of the atom, so far as it has yet been disclosed by Thomson, Rutherford and Bohr, is very adequately described. The quantum hypothesis of Planck which, by its success in predicting previously unsuspected phenomena, offsets the violence offered to our mechanical instincts, is clearly explained, and considerable space is devoted to the discussion of spectra, in which this theory has won perhaps its greatest triumphs. The translators we note have adopted the term "ionisation tension" for what is commonly called in this country "ionisation potential." There is a noteworthy section on the structure of crystals as disclosed by X-ray analysis.

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In the discussion of alternating-current problems there are two methods of attack. The first is that of complete mathematical analysis, involving a large amount of labour in obtaining a grasp of it. Graphical analysis, as an alternative, is available, but in the enthusiastic appreciation of the value of that method, authors of papers and books have sometimes so much elaborated the diagrams as to make it an open question whether the method has any advantage on the score of simplicity. Students of electrical engineering must understand both processes of tackling the problems, if they are to obtain a thorough knowledge of the subject. It must never be forgotten, however, that such readers do not take up the study of alternating currents as a mathematical recreation. For use by students the simplest methods of treatment are best, and whichever of the two processes is used must be settled on that understanding. There are some books, of course, in which the outlook of the student has been borne in mind, and to their number must be added "*Alternating Current Electrical Engineering*," by W. Tolmé Maccall, the head of the electrical engineering department of the Sunderland Technical College. This book was recently published by the University Tutorial Press, Limited, at 15*s.* net, and it has all those characteristics of presentation of the matter that make that firm's books so acceptable to students. It was prepared to serve as a text book on alternating currents, for students in the usual three or four-year courses in electrical engineering in technical colleges. It appears to be a very sound piece of work, and will be welcomed for its clarity by those who intend to sit for the various examinations in the subject. Where necessary the explanations are accompanied by worked examples and the matter is well illustrated with diagrams and details of plant.

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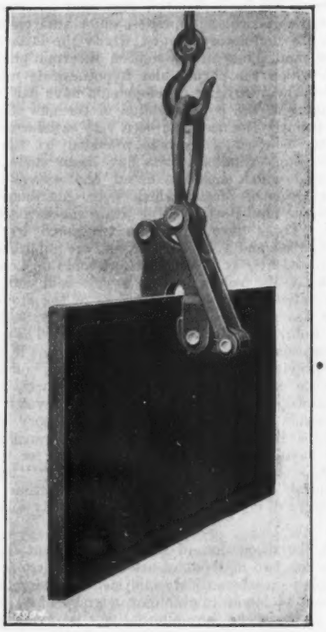
CONTRACTS.—The Paterson Engineering Company, Limited, Water Works Engineers, Windsor House, Kingsway, London, W.C. 2, have received a contract for the water filtration plant of 4,000,000 gallons daily capacity for the South Staffordshire Water Company's Lichfield Works, whose engineer-in-chief is Mr. Fred J. Dixon, M.Inst.C.E., M.I.Mech.E. The plant will include chemical treatment gear, sedimentation tanks, filters of the Paterson rapid gravity type, chlorine gas apparatus and effluent disposal plant, making altogether an exceptionally complete and comprehensive filtration works, for public drinking supply.

## LIFTING CLAMP FOR PLATES.

A clamp with a very effective grip for handling plates in shipbuilding yards and steel works is shown in the accompanying illustration. This was designed by Mr. A. G. Strathem, of Messrs. Weldless Chains, Limited, of Gartsherrie, Coatbridge, as one of the series of safety-lifting appliances which his firm manufactures.

It consists of a simple frame with a fixed gap, in which a movable jaw of cam shape is made to hold the plate against one side of the gap by pressures caused by the load. The hook pin is connected by a radius arm to the frame and by a pair of rods to the outer end of the lever whose end forms the movable jaw. When the clamp is slipped over the edge of the plate and the lifting tackle is operated, the plate is gripped between some part of the cam surface of the movable jaw, depending on the thickness of the plates, and the other



side of the gap. The heavier the load is, the greater will be the pressure applied to the plate. Any thickness of plate up to a little less than the width of the fixed gap may be dealt with and a range of sizes suitable for different classes of work are manufactured. The standard ones are designed for use with ½ ton, 1 ton, 3 tons, 6 tons and 10 tons, but clamps suitable for much greater loads and plate thicknesses have been constructed and are actually in use. The largest ones so far produced, were made for the United States Navy for handling armour plates, and have a gap of 13 in. width, and are capable of use with a plate weighing 75 tons.

Among the other safety lifting appliances made by the same firm are non-slipping lifting dogs, clamps for lifting packing cases and cask slings. The plate-lifting dogs have fixed jaws pivoted to simple cam lever movable ones, which are brought into action as the shock is taken out of the sling. Each cam lever has a ring at its end, through which the sling is passed for the purpose of applying the pressures on the plate caused by the load.

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Ciment Fondu.—The Lafarge Aluminous Cement Company, Limited, has been formed with registered address at Regent House, Kingsway, to work in this country under an agreement with the Société Anonyme des Chaux et Ciments de Lafarge et du Teil, the French company, whereby they acquire the sole selling and manufacturing rights in respect of the cement known as "Ciment Fondu," for Great Britain and the north and South of Ireland. "Ciment Fondu" to which we have frequently referred in these pages, has been manufactured for some years past by the French company. As the result of experiments carried out over a period of years by the French company and by Governmental Research Departments, this high alumina cement is now accepted in all classes of work by all public works departments, railway companies, and engineering institutions in France and her Colonies. As we have so frequently described the characteristics of this cement for further information we would refer our readers to the articles in question, and especially to one on page 180 of vol. cxiv of Engineering.

## ROAD MAINTENANCE MACHINES.

In previous articles* we have dealt with plant exhibited last summer at the Cardiff meeting of the Institution of Municipal and County Engineers, intended primarily for road construction. In this article we propose to deal with a few appliances exhibited at the same meeting, but intended more for upkeep. The first machine we illustrate is a tar-spraying machine which can be used either for grouting or for top dressing in connection with gritting. Several machines of this class were exhibited, the machine of Messrs. Thomas Coleman and Sons, Limited, of Derby, being reported upon as good with regard to design, workmanship, strength and durability.

This machine is illustrated in Figs. 1 to 7 on this and the next page. It consists of a tank of mild steel plate surrounded by flues, through which pass the hot gases from a firebox hung underneath the body of the machine. The gases pass from the firebox towards the rear of the machine and then forward again, escaping at the front end through a chimney. The firebox is totally enclosed and doors are provided for the flues for cleaning purposes. A large strainer is fitted to the tar tank opening, and raised rails are fixed on the top of the tank, on which the tar barrels can be placed. A swivelling wire rope hoist is also furnished to enable barrels of tar to be lifted on to the machine and lowered on to the rails. An angle iron surrounds the top of the tank as a precaution against boiling over, any fluid issuing by mischance from the tank opening being kept away by this means from the firebox and directed to the back of the machine.

Attached to the back of the tank is the tar distributor. In this arrangement no brushes are used, but the tar is fed on to a flapper of revolving blades. The blades extend all across the machine, the shaft and spiders on which they are mounted being chain driven from a short countershaft fitted with a clutch, which is well shown in Figs. 6 and 7. The countershaft is chain driven off a large sprocket on one of the large rear-carrying wheels, the double gearing introduced resulting in a high speed of revolution for the blades for a slow forward movement of the machine. The tar can be sprayed to a maximum width of 5 ft. 6 in., though the actual width can be adjusted by means of sleeves on the spray pipe, to a minimum of 2 ft. 6 in. The spray pipe is placed horizontally across the machine, just in front and rather below the axis of the distributor. The jets of tar strike ther evolving blades and the tar is atomised and beaten down on to the road surface with considerable force, resulting in good

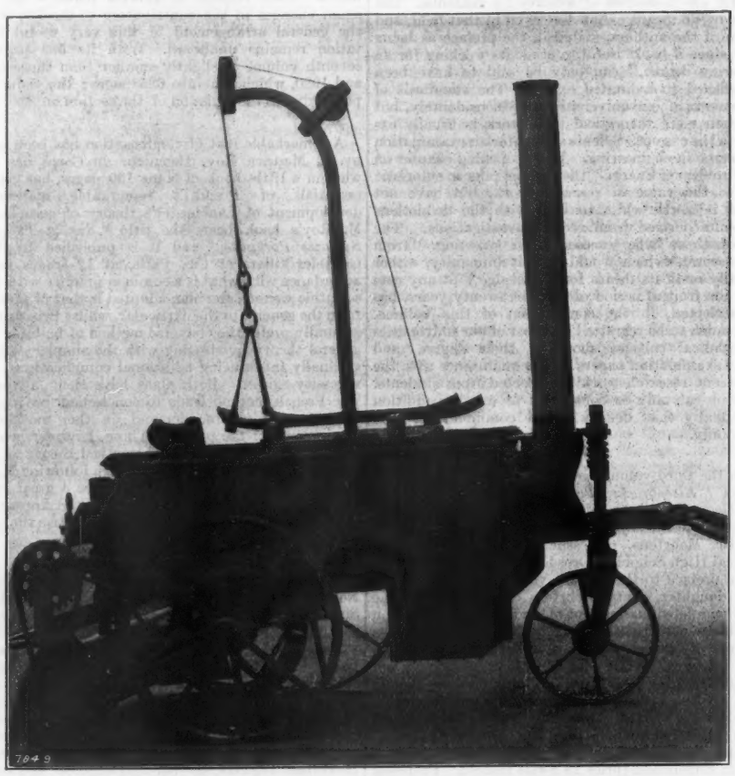

Fig. 1. The Coleman Flapper Tar-Spraying Machine.

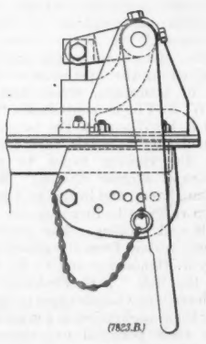

Fig. 2.

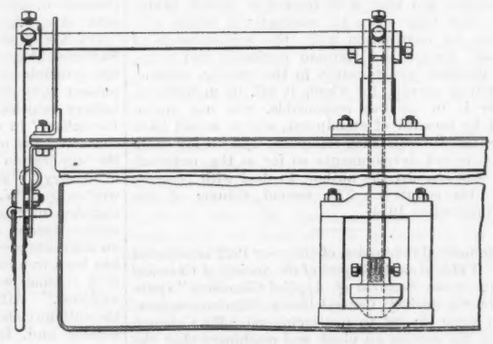

Fig. 3.

Figs. 2 and 3. Details of Tar Valve of Coleman Spraying Machine.

* See Engineering, Vol. cxv, pages 682 and 708.

penetration. A handle and cock at the back of the machine regulate the supply of tar to the spray pipe, adjustment of the distribution being possible between 3 yards to 14 yards to the gallon. The machine exhibited was one of 200 gallons capacity, though three sizes are built, of 160 gallons, 200 gallons and 250 gallons respectively. The distributor is fitted with a spray hood, and the back of the machine is fitted with an angle iron buffer. Figs. 2 and 3 illustrate an internal valve which may be adopted instead of the regulating cock shown at the rear. This valve enables bituminous compounds to be sprayed in the machine without any risk of clogging when the machine gets cold. The figures are self-explanatory. The machine requires a horse and driver and one man. It was reported upon as being good as regards accessibility of parts, ease of manipulation and operation, in good condition at the end of the trial, and of good all-round efficiency. No pumps or nozzles are employed, thus eliminating certain maintenance costs. The work done is about 8,000 super yards in eight hours. The quality of the work was reported to be good and the distribution even.

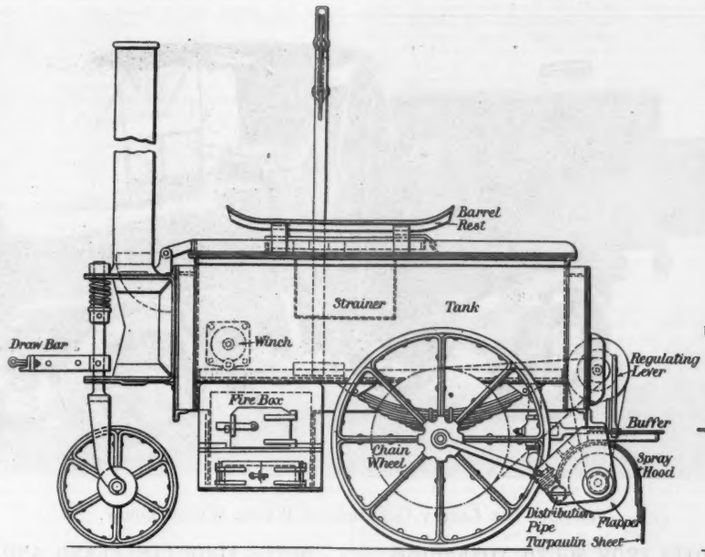


FIG. 4.

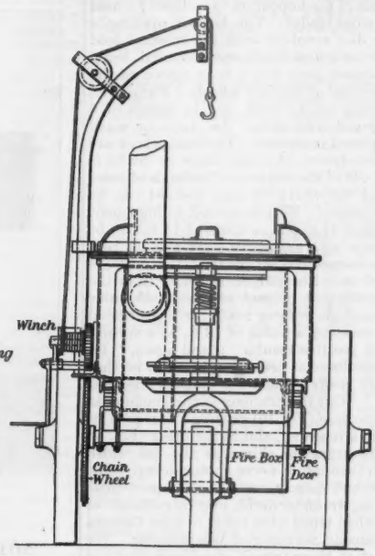


FIG. 5.

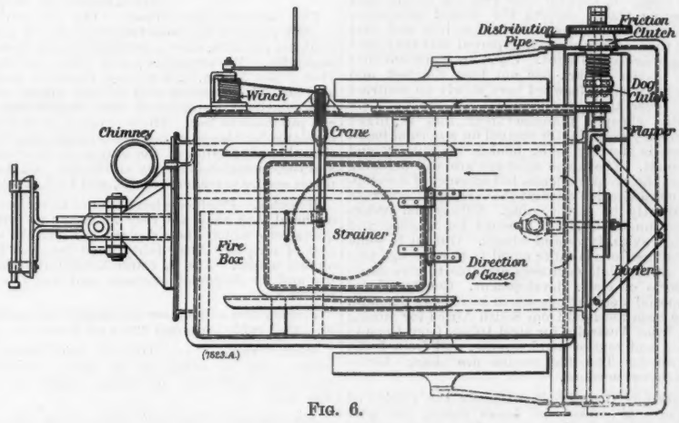


FIG. 6.

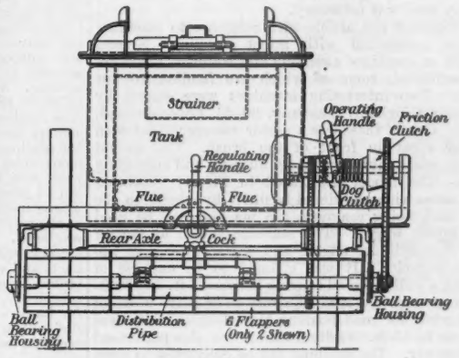


FIG. 7.

FIGS. 4 TO 7. THE COLEMAN FLAPPER TAR-SPRAYING MACHINE.

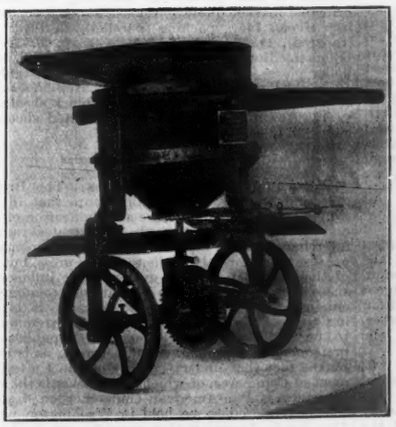

FIG. 8. THE SIMPLEX GRITTING MACHINE.

FIG. 9. SIMPLEX MACHINE GRITTING FULL WIDTH OF ROAD.

FIG. 10. SIMPLEX MACHINE GRITTING NARROW STRIP OF ROAD.

The Class for road and gritting apparatus did not result in many exhibits, though the little appliance we illustrate in Figs. 8 to 10 on this page, proved quite an attraction. The Simplex Gritting machine is constructed by Messrs. F. Walters and Co., Albert-street,

Rugby. This machine itself is shown in Fig. 8, while it is shown at work in Figs. 9 and 10. It consists of a small hopper on wheels. Arranged inside the hopper are a vertical feed screw and paddles, which feed the grit out through the bottom of the hopper on to a slightly coned disc fitted with radial blades. The hopper opening is adjustable. The disc revolves with the internal feed screw, the shaft on which both are mounted being driven by a two-speed gear fitted to a sleeve on the axle, and driven by one of the road wheels. The driven gear slides vertically on its shaft, and by means of a lever can be engaged with either the large or small driving gear, or placed in neutral. The road wheels are fitted with rubber tyres. A wing plate or baffle is arranged on each side of the machine. The angle of these is adjustable, and the width of road covered can be regulated by this means. With fine sand, in high gear, at a walking speed of 2½ m.p.h., a width of 14 ft. can be easily covered, while with granite or small shingle from 16 ft. to 30 ft. can be covered. At the trials this machine was well reported on. The judges, to quote from the report, "were particularly pleased with the uniformity with which the sand (in gritting roads for slipperiness) was distributed, covering a width of 18 ft. at a sprinkling with the best possible results"; and again, "Its special field of usefulness at present appears to be that of gritting slippery roads; which the judges consider it does excellently." Our illustrations of the machine at work show it in one case (Fig. 10) gritting a narrow 3-ft. track for horses in a roadway, and in the other (Fig. 9) spreading ¼-in. grey granite chippings the full width of a 24-ft. road, behind a 4-ton motor lorry. The machine is light and handy and is a compact little appliance. It was, we understand, first introduced at the end of 1921 when trials were made of it by Captain F. W. Cable, Cleansing Surveyor of Westminster. We are informed that at these tests it was found that the machine was capable of spreading ¾-in. grit for a width of 30-ft. behind a horse-drawn vehicle, and that owing to the evenness of the spread only half the material formerly used was necessary.

We conclude our article with reference to machines used in connection with street cleaning. Several sweepers or combined sweeping and watering machines were exhibited, some of which are familiar to our readers. Two interesting machines were shown by the Laffly (England) Company, 20–26, Lonsdale-road, N.W.6. One of these was a motor sweeper fitted with a water spray in front of the brush. The second machine was a motor watering, flushing and sprinkling wagon. The model illustrated in Fig. 11 combines these duties with additional facilities by which, on the water tank being removed, the machine can be used as a tipping wagon. The machine shown at Cardiff had a four-cylinder engine and a water tank of 750 gallons capacity. It was claimed to be capable of spraying a width of road ranging between 6 ft. and 50 ft. The judges reported it would spray an effective width of 60 ft., while for road flushing the effective width was found to be 15 ft. Gully flushing was also performed satisfactorily. The machine can be converted to work as a fire engine, either taking water direct from a supply, or from its own tank, and will draw through 30 ft. of suction hose satisfactorily, delivering 175 gallons per minute at 150 lb. pressure to a height of 105 ft. At the trials the delivery with a ¾-in. jet was 180 gallons per minute at 80 lbs. pressure. The machine can fill its own tank by means of the pump, taking in the 750 gallons in 4 min. It travels at speeds up to 20 m.p.h., and on a road test did 8¼ miles on 5 quarts of petrol. For pumping the consumption was 4 gallons of fuel per hour. As regards design, workmanship, etc., this machine was described by the judges as excellent, with excellent accessibility; and a very satisfactory all-round efficiency.

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Manchester Association of Engineers.—On Thursday, July 26, upwards of 200 members of the Manchester Association of Engineers, by the courtesy of Mr. Geo. Hughes, chief mechanical engineer of the London Midland and Scottish Railway, inspected the extensive locomotive works at Horwich. These works employ about 4,000 men, principally in the manufacture and repair of locomotives.

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The British Cast-Iron Research Association.—The last report issued by this association gives particulars of the research work it has on hand. This includes shrinkage defects research; foundry sand research; work in the matter of cast-iron to resist sea water which is carried out jointly with the Electrical Research Association; work on internal-combustion engine castings; work on cast-iron moulds for bottle-making undertaken jointly with the Glass Research Association; malleable cast-iron research. The association considers that the time has arrived when a standard specification for grey iron castings should be drawn up, and steps have been taken to have this carried out in conjunction with the British Engineering Standards Association. Further data can be obtained from the Secretary, Central House, New-street, Birmingham.

# ROAD MAINTENANCE MACHINE.

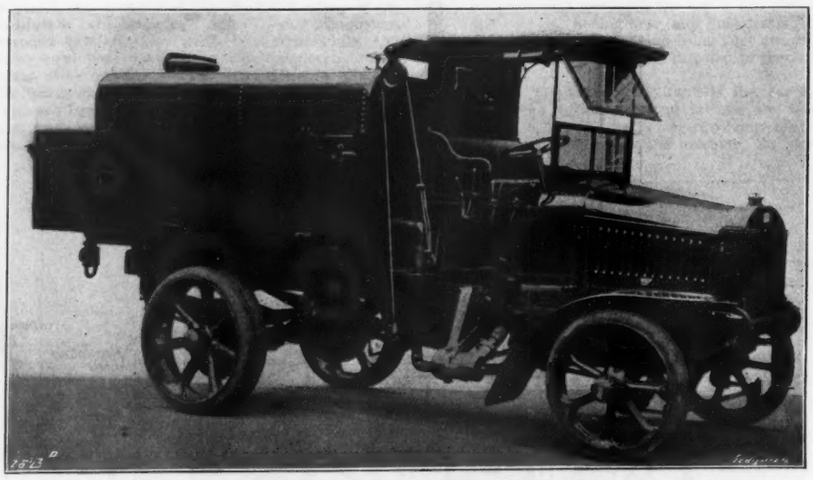

Fig. 11.—The Laffly Convertible Water Wagon Lorry.

## NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

*Iron and Steel.*—A hopeful tone prevails in the steel and engineering trades despite the dismal utterances made at political gatherings. Both basic iron and steel are cheaper than at any preceding period this year, and lower selling prices are in sight. Users are confident that the bottom of the market has not been reached, and accordingly are coming forward very slowly on contract account to cover their requirements for the next six months. Still cheaper manufacturing fuel is urged to be the primary essential for revival on a normal basis. New business is steadily being booked on railway and colliery account. The home railways are still delaying the placing of their requirements, but schemes of development under consideration warrant the view that important work will shortly be forthcoming. Substantial orders are in execution on Colonial account for wagons and wagon frames, axles, tyres and wheels. Output in some of the railway sections is quite equal to the average pre-war level. Automobile engineers are able to give satisfactory reports of trade development. Constructional parts and special steel fittings are in increasing demand. Orders have been received from South Africa for mining machinery, from Australia for steel tubes, from Canada for hardware and textile requirements, and from India for rolling-stock. The file trades are doing better business on export account.

*South Yorkshire Coal Trade.*—Despite the receipt of further reports of substantial losses during the past twelve months at the leading steel and iron works, home industrial requirements are steadily maintained. Collieries are well booked forward for steam fuel deliveries for inland and export and have only a workable margin of reserves. Railway companies and electricity works are big buyers. Prices of cobbles and nuts show fresh weakness, Derbyshire best small nuts having been marked down 6*d.* per ton on top of recent reductions. Output is being restricted at house coal pits. Quotations:—Best branch hand-picked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 26*s.* 6*d.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 20*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 18*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 7*s.* to 9*s.*

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Engineering Scholarship; University College, London.—A Goldsmid scholarship, tenable in the Faculty of Engineering at University College, London, of the value of 90*l.* (30*l.* a year for three years, subject to satisfactory progress), will be offered for competition at an examination to be held at the college in September. Particulars may be obtained on application to the secretary of the college.

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Lloyd's Register of Shipping.—The statistical summary of the vessels totally lost, broken up or condemned during the year 1922, was recently published by Lloyd's Register, and shows that the reduction of the effective mercantile marine of the world amounted in the year to 716 vessels of 887,812 tons. In this statement the vessels of below 100 tons are excluded. Of the total, 511 were steam or motor driven and having an aggregate tonnage of 743,866. These figures are greatly in excess of those for any year before or since the European War, but that is not due to actual casualties, but to the unusual number of vessels which have been broken up or dismantled. Those owned in Great Britain and Ireland, which are included in the list as broken up, dismantled, &c., accounted for 127,974 tons.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

*The Cleveland Iron Trade.*—The Cleveland pig-iron market presents few new features. No. 1 and siliceous qualities continue scarce, but demand for these grades is negligible. The former is put at 115*s.*, and the latter at 110*s.*; No. 3, g.m.b., is not too plentiful, and is steady at 104*s.* 6*d.* Foundry 4 is in very ample supply, and fails to attract customers at 100*s.*, buyers reporting they can purchase at less. There is not a great deal of forge available for the open market, makers absorbing a considerable proportion of the output in their steel works, and the quotation is steady at 97*s.* 6*d.* All the foregoing prices are f.o.t. makers' works, and f.o.b. Tees.

*Hematite.*—Producers have a lot of East Coast hematite on hand, but they are very reluctant to further lower quotations which they declare are already well below cost of output. After fairly good business buying has almost ceased. Nos. 1, 2 and 3 stand at 100*s.* for home use and for shipment overseas, and No. 1 is 6*d.* above mixed Nos.

*Foreign Ore.*—Business in foreign ore is little heard of. Best rubio is quoted 23*s.* c.i.f. Tees.

*Blast-Furnace Coke.*—Durham blast-furnace coke is scarce, and is stiffening in price. Consumers now experience difficulty in finding sellers at under 41*s.* delivered.

*Manufactured Iron and Steel.*—Most descriptions of manufactured iron and steel are very slow of sale and easy in price, but in one or two departments rather more inquiry is reported. Sheet makers have sold well and demand is still good. The following are among the principal market quotations:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.* 10*s.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; steel joists, 9*l.* 15*s.*; heavy steel rails, 10*l.*; fish plates, 14*l.*; black sheets, 13*l.* 5*s.* to 13*l.* 15*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 18*l.* 15*s.*

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Pan-American Standardisation.—The British Engineering Standards Association state that in America simplification in manufacture and unification of methods and works, tending towards the greatest amount of interchangeability, especially in small component parts, are discussed not only in the technical press, but in many of the daily papers also, owing to the influence which these two requisites have on national economy in the elimination of waste. At the moment it is interesting to note that America is making strenuous efforts to persuade the South American Republics to give preference to American manufacturers, as is evidenced by the fact that under the ægis of the United Department of Commerce, of which Mr. Hoover is the very able Secretary, a Pan-American conference on Standardisation is proposed to be held in Washington next year. The South American Governments are to be invited to participate in the conference, and it is presumed that the governing idea will be to endeavour to obtain the adherence of the various American Governments to United States standards. It appears to be a fact that American manufacturers, except in special lines, are not foremost as exporters of industrial products, they concentrate more on domestic demands, while European industries are heavily dependent on their export trade. The proposed Pan-American Conference on Standardisation would certainly seem to be a movement which merits the closest attention of British manufacturers.

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scottish Steel Trade.*—The majority of the steel works in Scotland have now made a start again, but unfortunately in most cases there has been little accumulation of work to commence to and still less to carry on with. Buyers continue to exhibit great backwardness in giving out fresh business, and do not seem inclined to commit themselves to any extent whatever. It is generally known that many of the buyers who have orders to place are holding back as long as possible in anticipation of an early reduction in prices. The trouble in the shipyards is not helping business, and is now a very serious affair indeed. For shipbuilding material there is practically no demand at all, but makers of structural sections have a few orders on hand. Black sheet makers have quite a fair number of orders on their books, but the largest percentage is on export account and consists almost wholly of the thinner gauges. Prices all round are without change and are as follow:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

*Malleable Iron Trade.*—The resumption of work after the holidays has not been a very brilliant one in the West of Scotland malleable-iron industry on account of the general depression of trade. Order books have not been filling up satisfactorily, and no distance ahead can be seen. Inquiries are not very plentiful either and the outlook is not considered very bright. Prices are unchanged with "Crown" bars called 12*l.* per ton, delivered Glasgow.

*Scottish Pig-Iron Trade.*—No change can be reported in connection with the Scottish pig-iron trade, and not only is the local demand very poor, but foreign buyers are not very plentiful at the moment. Hematite iron continues very dull and the consumption of foundry sorts is also very small at present. The following are to-day's prices:—Hematite, 5*l.* 16*s.* 3*d.* per ton delivered at the steel works; foundry iron, No. 1, 5*l.* 10*s.* 6*d.* per ton, and No. 3, 5*l.* 5*s.* 6*d.* per ton, both on trucks at makers' yards.

*Scottish Pig-Iron Shipments.*—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, July 28, amounted to 2,923 tons. Of the total, 2,742 tons went foreign and 181 tons coastwise. The figures for the corresponding week last year were 225 tons foreign and 132 tons coastwise, making a total of 357 tons.

*Scottish Shipbuilding.*—The Scottish shipbuilding returns for the past month make very unpalatable reading on account of the very low output recorded. The figures were as follow:—

| | Vessels. | Tons. |
|---|---|---|
| The Clyde ... ... ... | 5 | 754 |
| The Forth ... ... ... | — | — |
| The Tay ... ... ... | 1 | 150 |
| The Dee and Moray Firth ... | 1 | 580 |
| | 7 | 1,484 |

The Clyde total of 754 tons is one of the poorest returns on record, and the only worse figure was the 25 tons for April of last year. Last month's total compares badly with the 32,900 tons of July a year ago, but it is valueless to make much in the way of comparison on account of the different set of circumstances now prevailing. The lock-out of boilermakers continues, and it would seem as if a solution of the present difficulty is as far off as ever. At any rate there has been no progress made recently and the outlook is still clouded. New contracts are very scarce, but a few were given out during the month, most of which were, however, for vessels of a particular type or for a special purpose.

PERSONAL.—Mr. John Harper Narbeth, C.B., C.B.E., Assistant Director of Naval Construction at the Admiralty, has retired after forty-six years of service.

NATAL COAL.—According to *The South African Mining and Engineering Journal*, the reports on a vast new coal area at Pivaan, in the north-east corner of the Province of Natal, have tended to strengthen—if such aid were needed—confidence in the future of Durban, and its economic development. The Government Inspector has confirmed the statements of the consulting engineer of the Durban syndicate which owns this embryo coal-mining district. The chairman of the syndicate, Captain C. V. Hardcastle, is optimistic concerning the importance of the new area. He points out that samples of steam coal taken from seven adits on the hillside show an average of 77·21 per cent. of fixed carbon, as compared with an average of 70·55 per cent. of the six best Natal collieries, and that the percentage of ash is 6·51, as compared with that of 9·75 of the six collieries mentioned. The No. 1 Admiralty standard of fixed carbon percentage is 81·9 and the No. 2 standard 76·97. Altogether, it is claimed, the dry steam coal strongly resembles the best Welsh product. The field is also reported to contain coal suitable for gas and coke production and torban and ordinary oil shales. It is calculated that there are 200,000,000 tons of steam coal alone, without reckoning bituminous deposits occurring over an area of about 10,000 acres. The syndicate is hoping eventually to compete in the Indian and Eastern markets, as well as at Port Said and Alexandria, if not in Italy. It is interesting to note that the area is only about 125 miles from Sordwana Bay, and will touch the proposed Pongola Valley railway by means of which the coast belt of Northern Natal would be served.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Coal Trade.*—The Great Western Railway Company, the owners of the South Wales Docks and Railways, have decided to reduce their charges for the transport of coal, coke, patent fuel, pitwood, &c., on August 7, from 60 per cent. above pre-war to an increase of 50 per cent. This is the fifth reduction made since January last year, when the rates were 125 per cent. above the pre-war level. In June, 1922, the increase was reduced by 25 per cent., in January last by a further 25 per cent., and in July by 15 per cent. Meanwhile the coal market has developed a rather steadier feeling though the volume of business remains restricted and prices are not materially altered. With the approach of the holidays, however, buyers have apparently been more disposed to place orders, and the result is that in several cases collieries, who a week ago were anxiously seeking new orders, are now more comfortably placed, and consequently adhering more firmly to quotations. This applies in particular to large Monmouthshire coals which have of late been bought rather extensively for Italy, and some of the best Admiraltics, too, are well sold. A number of collieries are still in need of business, and buyers, except where they are tied to particular coals, can still secure their requirements at 6*d.* to 1*s.* per ton below the figures asked by the collieries which are well placed with orders. The dock position too is more favourable to sellers. A week ago there were a number of idle berths at all the ports, but at present all the available appliances are in use, and there are now several vessels waiting to go under the tips, which helps to keep pits working regularly. Again, outputs next week will be considerably reduced by the holidays, and standing stocks of coal will also be diminished. During the week the Cardiff Local Committee decided, in view of the present reduction in the volume of the export trade, to reduce the number of appliances working on the third shift to eight at Cardiff, nine at Barry and three at Penarth, which represents a reduction of four at each of the two former ports and one at Penarth. Notwithstanding this decision the coal tippers are still pressing their organisation to give one week's notice to terminate the third shift, being of the opinion that night work is unnecessary and that all the coal offered for shipment can be despatched during the day. It may be of interest to mention that to-day the Cardiff-owned steamer Polcevera, belonging to Mr. H. J. Giffin, sailed from Newport to Rio de Janeiro with the largest cargo ever despatched from the port in one vessel. She is taking 13,783 tons of coal, 11,809 tons cargo and 1,974 tons bunkers, all of which was loaded at one tip in eight working days and two nights. The previous record cargo left the port twenty-seven years ago in the steamer Algoa, which took 11,672 tons. Exports of coal from South Wales last week totalled 582,034 tons, or 45,000 tons less than in the previous week. Of the total, 225,590 tons were despatched to France, 77,680 tons to Italy, 90,940 tons to South America, 42,810 tons to Spain, 14,820 tons to Portugal, 4,900 tons to Greece, 51,440 tons to British coaling depots, 11,800 tons to Canada, 16,030 tons to Belgium, 11,240 tons to Holland, 17,070 tons to Germany, and 17,600 tons to "other countries." Exports of patent fuel amounted to 23,570 tons and coke to 5,990 tons.

*Iron and Steel.*—An agreement has been reached by the Welsh Tinplate Industrial Council in regard to the 19 claims of the men. Matters affecting the bundlers, annealers and assorters have been referred to committees for investigation, as also were claims by risers and pointers in reference to Player's timing machines. In respect to the 3¾ per cent. increase on the last ascertainment under the sliding scale, the employers agreed to continue their 7½ per cent. payment for another three months, and to give the men the 3¾ per cent. also, making a total of 11¼ per cent. for the next quarter.

THE TURBINE STEAMER "CUBA."—In the description of the T.S.S. "Cuba," in our issue of July 27, it was not made as clear as it might have been that the floating-frame reduction gearing for the turbines was manufactured by the Metropolitan-Vickers Electrical Company, Limited, of Manchester. The turbines were constructed under licence from the Metropolitan-Vickers Company by Messrs. Swan, Hunter, and Wigham Richardson, Limited, the builders of the vessel.

FRENCH AEROPLANES FOR DENMARK.—Denmark has hitherto had no regular military aeroplane fleet, but a move is now about to be made, and as a commencement eight large reconnoitring planes, all of the same type and size have been ordered from a French firm. They are biplanes, having 370-h.p. engines; their speed is to be fully 125 m.p.h. The armament will consist of three machine guns per aeroplane; the price, exclusive of the machine guns, will be about 2,000*l.* per plane, inclusive of spare parts.

ROYAL AERONAUTICAL SOCIETY.—We are informed that Mr. Alec. Ogilvie has been elected chairman of the Royal Aeronautical Society for the session 1923–24, in succession to Professor L. Bairstow, whose term of office will expire on October 1 next. The second examination for the election to the grade of associate fellow will be held in the society's library, at 7, Albemarle-street, London, W. 1, on September 24 and 25 next. Intending candidates should forward entry forms, which may be obtained from the secretary, on or before August 27, stating the subjects in which they wish to be examined.

## NOTICE OF MEETING.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, August 4, at 2 p.m., in the Lecture Theatre of the Institute, Newcastle-upon-Tyne. Annual general meeting.

PUBLIC WORKS, ROADS AND TRANSPORT EXHIBITION.—The Public Works, Roads and Transport Congress and Exhibition, which will be held at the Royal Agricultural Hall, Islington, N., from November 22 to 29, promises to be even more successful than its predecessors. The number of exhibitors already exceeds that of previous similar exhibitions, and the different classes of exhibits, whilst common to public works and municipal undertakings, are of such diverse natures that they will be of extreme interest to all branches of the engineering community, as well as to the general public. In addition to the road firms exhibiting, firms specialising in water undertakings and sewerage schemes will occupy a large area of the building. The congress, as in previous years, is being organised under the chairmanship of Sir Henry P. Maybury, K.C.M.G., C.B. The address of the managers is 13, Victoria-street, S.W. 1.

SOCIETY OF GLASS TECHNOLOGY.—In connection with the visit of members of the Society of Glass Technology to France, during the first week of July, two meetings with French glass manufacturers were held on Monday, July 2. In the morning, the visiting party was received by the Chambre Syndicale des Maitres Verriers, and was welcomed by its president Mr. L. Houdaille, who described to the visitors how the French glass manufacturers were all united in one body—the Chambre Syndicale—which was divided into six sections representing various branches of the industry. The work of these sections was organised in such a way as to prevent ruinous competition between members, and at the same time encouraged individual research and development. Mr. L. Delloye spoke of the need for co-operation among manufacturers of different countries. Professor W. E. S. Turner, Colonel S. C. Halse and Mr. E. A. Hailwood replied for the Society of Glass Technology. In the afternoon (after a lunch at which visiting members were the guests of the Chambre Syndicale des Maitres Verriers) a joint meeting of the Société des Ingénieurs Civils and the Society of Glass Technology was held. In the absence of Professor Guillet, president of the Société des Ingénieurs Civils, Mr. L. Delloye welcomed the visitors. The following papers were communicated: "La Méthode Scientifique dans L'Industrie," by Professor H. Le Chatelier; "Les Verries Opaques et Colorés, et les Glaçures Céramiques de Meme Espece," by Dr. A. Granger; "La Dilatation des Verries et Cristaux," by M. Lafon; "Specifications for Glass Products," by Professor W. E. S. Turner; "Improvements in the Design of Recuperative Glass Pot Furnaces," by Mr. T. Teisen; "The Physical Properties of Boric Oxide Glasses," by Mr. S. English and Professor W. E. S. Turner. During the week visits were paid to the following glass works: (*a*) Etablissements Legras at St. Denis, (*b*) Verreries de Reims (Messrs. Charbonneaux et Cie.), (*c*) new plate glass works at Chantereine, (*d*) Glaceries de St. Gobain, Chauny and Cirey. Members also enjoyed a number of social functions kindly arranged for their benefit.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, OPTICAL ENGINEERING.—One of the many difficulties which confronted this country at the beginning of the war arose from the fact that Great Britain had depended largely upon Germany for supplies of optical glass and British optical manufacturers had had practically no experience in the mass production of optical munitions of war. To remedy this state of affairs and so far as possible to make a recurrence impossible, the Government, in the year 1917, acting through the Board of Education and the Department of Scientific and Industrial Research in conjunction with the London County Council and the Governors of the Imperial College, established at the Imperial College for a period of five years in the first instance, a Department of Optical Engineering and Applied Optics, under the general control of a committee representative of the various Government Departments concerned and the scientific societies and trade organisations, with the Right Hon. Sir Arthur Acland, Bart., P.C., as chairman. This department was placed in the charge of Professor Cheshire, C.B.E., as director, who, with the late Mr. Esslemont, had been responsible for the creation and administration of the Optical Munition Department of the Ministry of Munitions. As the department was originally sanctioned for five years only, the question of its future has recently come up for consideration. It is very satisfactory to know that optical engineering and applied optics has now been put upon the same basis as regards permanency as the other departments of the college. The department is doing good work. The associateship of the Royal College of Science has been awarded to those students who have successfully completed the prescribed course of training, and past students are now beginning to make their influence felt in the optical world. Recognising, however, the pioneer character of the work to be done, all the lecture courses have been thrown open. Thus, except in the case of associateship students, any single lecture course can be taken without any obligation being incurred to attend other courses. In this way a considerable number of students have been dealt with, and it is perhaps not too much to assume that optical manufacturers in this country will never again find themselves in the unhappy position of 1914.

# THE IMPROVEMENT OF THE PORT OF LAGOS, NIGERIA, WEST AFRICA.

MESSRS. COODE, FITZMAURICE, WILSON AND MITCHELL, ENGINEERS, WESTMINSTER.

(*For Description, see Page* 137.)

FIG. 10. VIEW OF ENTRANCE TO HARBOUR IN 1909.

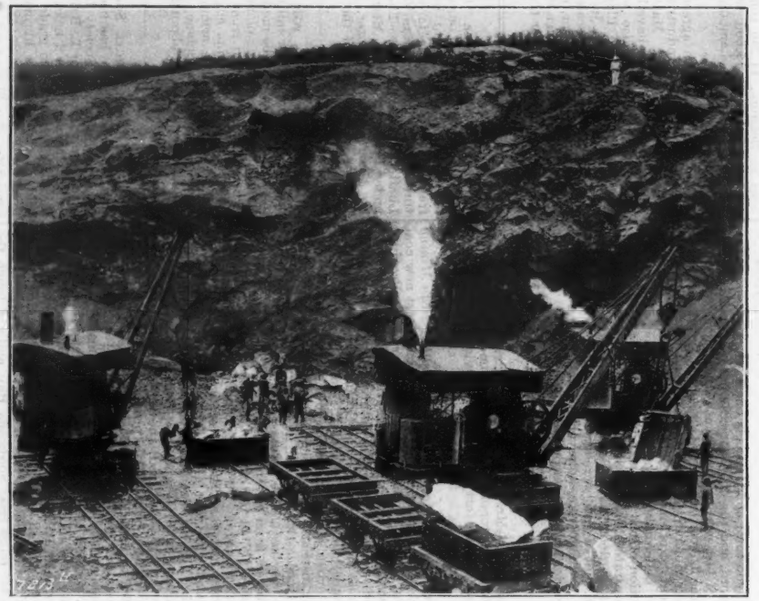


FIG. 11. QUARRY AT ABESKUTA.

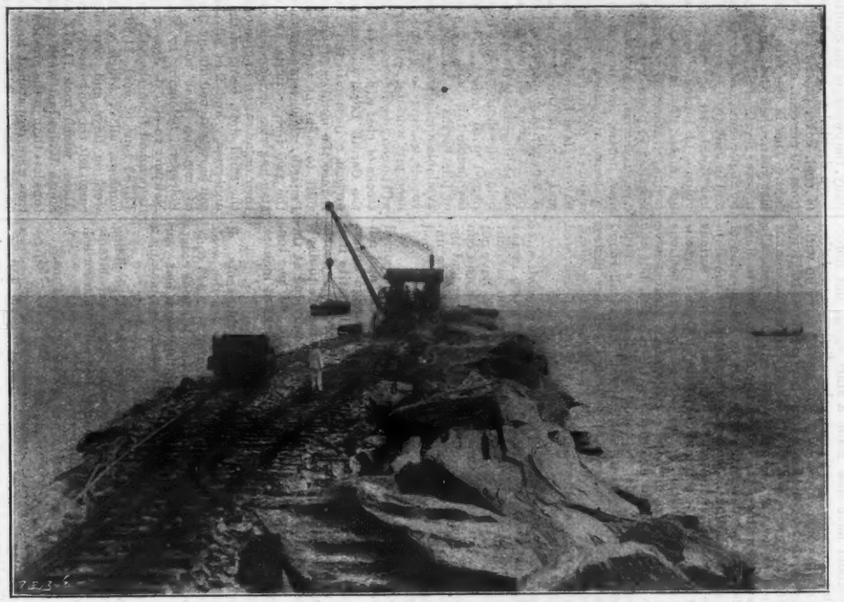


FIG. 12. WEST MOLE DURING CONSTRUCTION.

# 6-TON MOTOR VEHICLE FOR SERVICE

CONSTRUCTED BY MESSRS. HALLEY'S INDUSTRIAL MOTORS, LTD.

(For Description see Page

Fig. 1

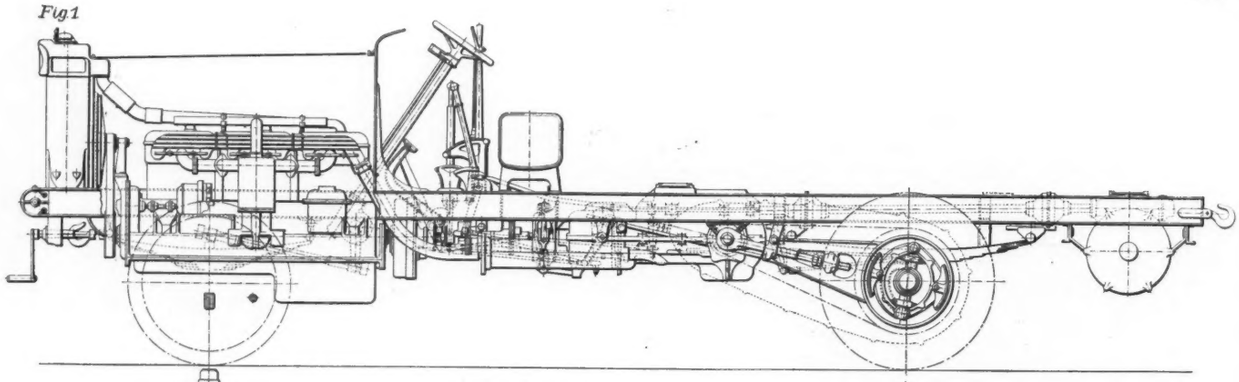
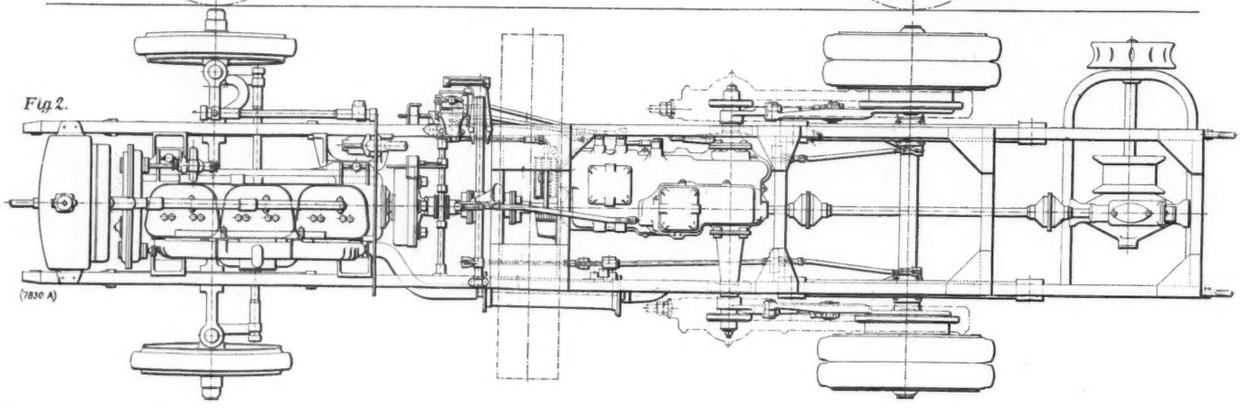


Fig. 2.



(7830 A)

Fig. 3.

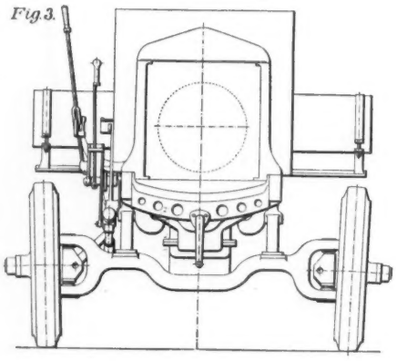


Fig. 4.

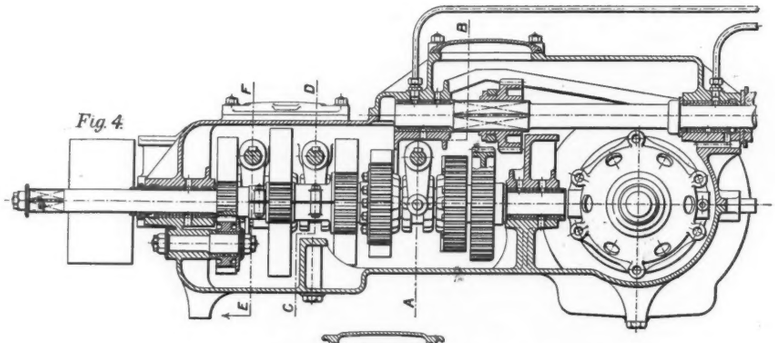



Fig. 7.

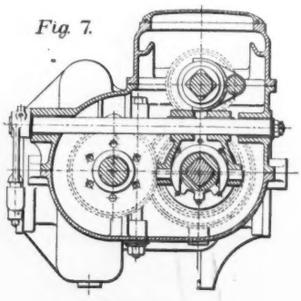


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Fig. 6.

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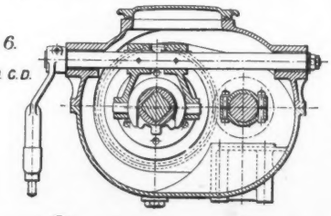

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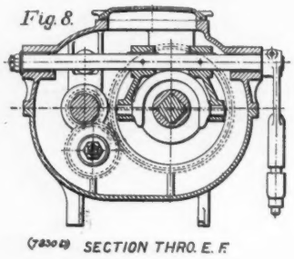

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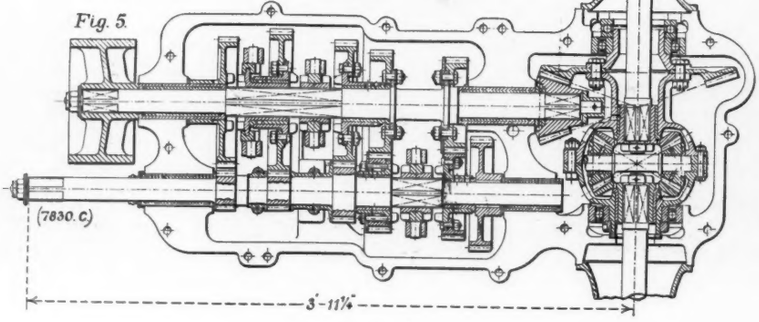
Fig. 5.



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LEY'S IND TRIAL MOTORS, LIMITED, YOKER, GLASGOW.

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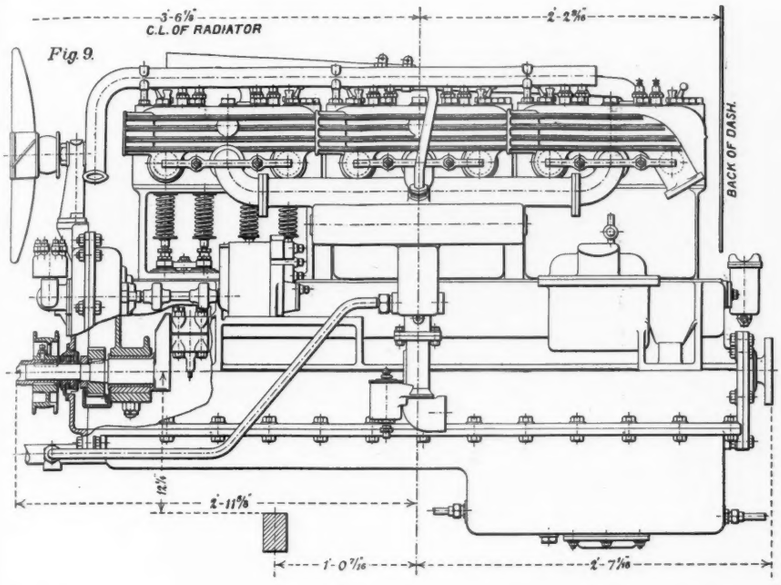
Fig. 9.

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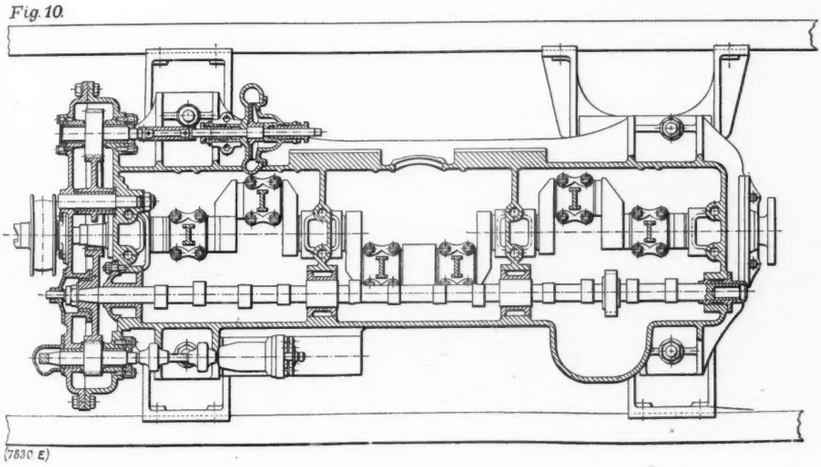

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CROSS SECTION OF SIXTH CYLINDER & GOVERNOR.

Fig. 11.

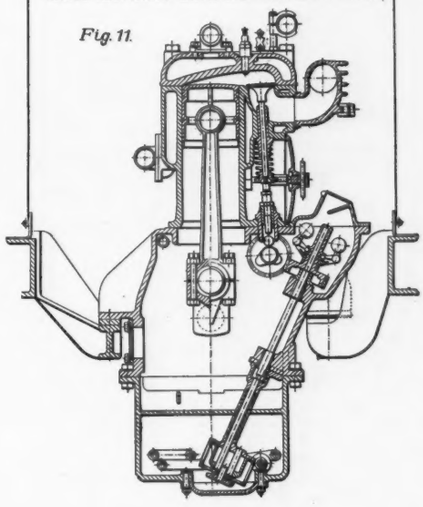
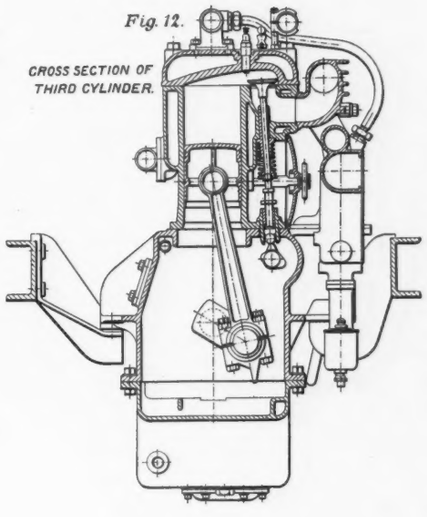
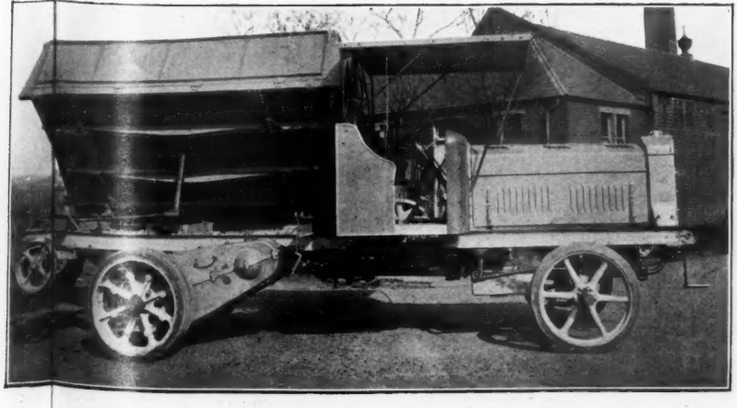


Fig. 12.

CROSS SECTION OF THIRD CYLINDER.





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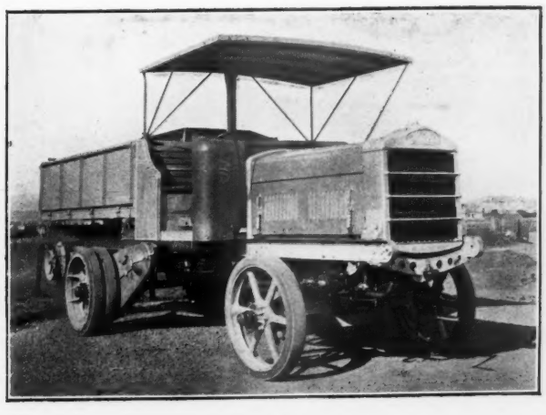

FIG. 14.

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*Two-Page Plate.*—6-*TON MOTOR VEHICLE FOR SERVICE AT HIGH ALTITUDES.*



# ENGINEERING.

*FRIDAY, AUGUST* 3, 1923.


## MAIN LINE RAILWAY ELECTRIFICATION.

THE Industrial Group in the House of Commons had devoted much time and attention to considering the steps which can be taken in order to reduce the extensive unemployment with which this country will be faced in the forthcoming winter, and has addressed a letter to the Prime Minister setting forth some of the principal profitable works which might be put in hand. Amongst these it attaches the greatest importance to the electrification not only of suburban railways but also of some of our main lines, pointing out that there is no class of undertaking which will give greater employment to skilled workmen in their own trades and in the districts in which they reside.

We have in the past devoted a considerable amount of space to the discussion of this important subject, and have referred to the progress of main line electrification both on the Continent of Europe and in the United States, while important contributions to the matter have been made in papers by Sir Vincent Raven, the late chief mechanical engineer of the North-Eastern Railway, Sir Philip Nash, late technical adviser to the Ministry of Transport, and others, which we have reproduced. Whilst it is premature to suggest that the steam locomotive will be superseded, there are numerous cases in this country where the electrification of portions of our main lines might well be taken in hand with a certainty of profitable results ensuing.

The questions involved in main line electrification are not as well understood in this country as they might be, and there is still an impression abroad that this class of work is only worth proceeding with in mountainous countries and in the case where coal is expensive and water powers are abundant. Furthermore, as in all new developments, a considerable amount of prejudice exists against the introduction of novel methods with which the officials of many of our railways are but imperfectly acquainted. The same prejudices had to be faced when electricity was first introduced on the suburban sections of some of our railways, and it was only the serious competition of electric tramways and motor omnibuses which eventually forced them to adopt this course and to follow the lead taken in this direction by the United States.

The results achieved have in all cases fully justified electrification, as is well illustrated by the financial success achieved by the conversion of the Liverpool and Southport lines of the Lancashire and Yorkshire Railway, the Tyneside lines of the North Eastern Railway, the suburban lines of the London, Brighton and South Coast Railway, of the South Western Railway, and of the Manchester and Bury section of the Lancashire and Yorkshire Railway. In the case of the Brighton Railway alone was it contemplated from the beginning that the main line should be eventually electrified, and a system was adopted, which since then has been employed in connection with the bulk of the very considerable electrifications either completed or in progress on the Continent of Europe as well as in connection with the very extensive main line electrification of the Virginian railways.

Some of the great advantages which may be expected from main line electrification and which have been fully realised in all cases where this system has been adopted, have been pointed out by Sir Vincent Raven, who has shown in connection with his proposal to electrify the main line between York and Newcastle, that there would be an annual saving of about 500,000 tons of coal per annum, and that a further saving would be effected due to the fact that the low grade fuel which could be burnt in the electric power station would be substantially cheaper than the high grade locomotive fuel. He has also pointed out that the electric locomotive possessed other great advantages, such as its simplicity in mechanical construction and operation and increased power of acceleration giving higher schedule speed, resulting in increased use of existing tracks. The electric locomotive also gives better adhesion at starting and on gradients, facilities for driving from either end, better accommodation for the locomotive crew and lower maintenance costs. The better balancing results in lower cost of maintenance of track, while the costs of train and maintenance staff are reduced. If we are going to get railway companies to pay their way in the future and at the same time to reduce railway charges, it will only be possible to do this through economy and by saving in the cost of labour and fuel, and the only way of achieving this is by main line electrification where the traffic is such as to justify this step, as Sir Vincent Raven satisfied himself would be the case from York to Newcastle.

The late chairman of the London, Brighton and South Coast Railway, in his address to the shareholders in February of last year, referring to the electrification to Brighton, stated that he considered it a duty to the shareholders and to the public to get ahead with this work with the least delay, and that if they had been independent they would have done so. He furthermore stated that in order to satisfy themselves on the results to be anticipated by such an electrification, he had obtained the services of the highest available authorities, and that the conclusions of this investigation were of such a character that he was convinced that it was only by carrying out such a programme that they could hope to maintain the dividends on the line. Not only have views of this nature been expressed by Sir Vincent Raven and the late chairman of the Brighton Railway Company, but views equally strong are held by men like Sir William Forbes, Sir Philip Nash, and Sir John Aspinall. Sir John Aspinall has stated that in his view electrification of goods yards would result in a considerable saving in the cost of shunting operations and that great benefits would result in the electric hauling of goods trains ; while Sir William Forbes has repeatedly referred to the great benefits which the railway company and the public would derive from the electrification to Brighton, and to the necessity of electrification at this critical period of railways and of the country.

In view of such opinions expressed by British

experts and railwaymen it is interesting to consider the position as regards main line electrification in this country to-day. The electrification between York and Newcastle has been indefinitely postponed, and the retention of the single-phase system on the Brighton Railway has been made a matter of discussion which, if persevered in, is likely to lead to the indefinite postponement of that main line electrification also. In both these cases the officials best acquainted with the particular requirements of the lines over which electrification was proposed have been replaced by others, whose interests appear to be more nearly concerned with the steam locomotive, and who therefore do not look upon main line electrification with any extreme enthusiasm.

It may be that in some quarters it is considered that it would be better to spend large sums on station improvement, new railway lines, docks and harbours, rather than on main line electrification. These would provide work, but not for the skilled artisan or for our large industrial works all over Great Britain. There is no reason why these improvements should not be proceeded with, but the others should not be neglected, and from the industrial point of view they are by far the more urgent. Other countries have realised this fact more than we appear to have done. France is spending vast sums of money on main line electrification; Holland has decided to start electrifying her main lines; Italy has carried out electrification on a large scale and further works are in progress; Switzerland is hard at work converting the whole of her railways to electric traction, some 500 km. are already electrified and a further 1,100 will be converted by 1928; while Germany has electrified, or is electrifying, 800 miles, Austria 500 miles, Sweden 280 miles.

It has been estimated that there are electrification schemes in this country, involving an expenditure of some fifty millions of money, which are so far advanced that contracts for most of the work could be placed almost immediately, thus giving employment for the next two or three years to a very large number of skilled workmen in our factories all over the country. The mere prospect of such work would be of the most material benefit to employers and employed, both of whom are rapidly loosing heart as they approach the fourth year of unemployment. The placing of such orders, distributed as they would be over a lengthy period, would help to keep down standing charges and greatly increase the capacity of British industry competing for foreign orders. It would encourage other orders, as experience has shown that it is when industry is flourishing that new enterprises find the most encouragement.

The prosperity of our railways is bound up with the prosperity of our industries, on which they depend for their existence, and by encouraging industry the railways will be benefiting themselves. In asking the railways to lay out main line electrification such as we have referred to and such as are a modern necessity in the Midlands, in Lancashire, in Yorkshire, in South Wales, round Glasgow and elsewhere, they are not being asked to carry out any untried experiment, but to follow the lead of the United States and the Continent of Europe, where the results of main line electrification have surpassed the expectations of the most ardent advocates of this system of haulage.

## THE AUSTRALIAN MAIL SERVICE.

We all know from sad experience that although our pre-war postal service was far from ideal, the facilities offered to the public had to be reduced very substantially during the war, and have not yet been restored to even the pre-war standard. It appears that this applies also to the trans-oceanic mails and that the mail services to Australia are fewer than before the war, although Australia looms much larger in the popular imagination than it did ten years ago. Before the war the Orient and P. & O. between them gave a weekly mail service to the antipodes, while to-day, although the Australian Commonwealth is running a service of its own, there are now but 41 mails in each direction per annum. The question of improving transport conditions in this service was raised at the Imperial War Conference held in 1918, and this led to the appointment of a committee to study the whole question. In a report* just published the committee come to the conclusion that there would be little or no advantage in increasing the frequency of the service, and that a faster service can only be secured by an increase in the present subsidies.

The amount of this increase required would vary widely with the route and the means of transport used. There are four routes open to the mails, viz. overland from London to Toulon or Taranto and thence via Suez to Fremantle in West Australia. At this port the mails are transhipped and sent on by rail to Melbourne and Sydney. The total length of the journey from London to Melbourne by this route is 10,784 sea miles via Toulon and 10,675 sea miles via Taranto, and about one-third of the whole distance is traversed by rail. The Cape Route is 12,709 miles in total length, of which 1,884 nautical miles are land transit. Another route via the Panama Canal to Sydney and thence by rail to Melbourne measures 12,994 nautical miles from London to Melbourne, but the mails have a land journey of 513 miles only. A fourth suggestion is that the mails should take advantage of the high-speed service from England to America and be carried through Canada to Vancouver and thence by ship to Sydney and Melbourne. On this alternative the sea route would be 9,322 nautical miles and the land transit 3,860 nautical miles, making a total of 13,182.

It will be seen that the Suez Canal route has a very great advantage in the matter of distance, and particularly distance by sea. It has also a further advantage in that the length of run between bunkerings is less than by any of its rivals. The longest run without an opportunity for re-coaling is 3,390 miles via Suez. 6,480 miles via the Cape, and 7,692 miles via Panama.

Much as the Cape route may appeal to a natural sentiment, the Committee have had to decide against any attempt to effect any substantial improvement in the speed of services by this route. The Suez route, however, presents greater possibilities.

It will be remembered that when it was decided to build the Lusitania and Mauretania, it was found that there would be no advantage in producing boats having speeds of but a knot or so higher than those of steamers already in service. In order to secure convenient times for arrival and departure a much greater increment of speed was essential, and somewhat similar considerations apply to the Australian service. The Post Office declare that Thursday is the only convenient day for despatching the Australian mails, and as the consequence a moderate increase in the 15 knots average sea speed now maintained would land the mails at Fremantle early on Sunday or late on Saturday night, and the Australian dockmen do not work on Sundays. Hence, for a satisfactory fast service a substantial increase in the present average speed over the whole distance would be necessary, and this, if it were secured by building faster boats, would, the committee point out, be very costly. On this head they have collected some extremely interesting data. It is economically impracticable to attain higher speeds without a very substantial increase in tonnage; and even if high-speed boats are built correspondingly larger, the cargo capacity is reduced at least relatively and in most cases absolutely. The first cost and running expenses are also, of course, higher.

This is very clearly shown by the following figures given in the report:—

| Size of Vessel. | Gross Tonnage | Average Sea Speed. | Relative First Cost. | Relative Revenue Required. |
|---|---|---|---|---|
| ft. ft. ft. | | | | |
| 580×66 ×49 | 15,500 | 16 | 100 | 100 |
| 600×72 ×50 | 18,500 | 18 | 125 | 130 |
| 635×74·5×51 | 21,500 | 20 | 160 | 180 |
| 760×87·6×60·6 | 30,704 | 25 | 250 | 290 |

It is added, that whilst the first vessel in the table would have a dead-weight cargo capacity of 3,500 tons, the last vessel on the list would have no cargo capacity whatever. The above estimates are based on existing methods of ship propulsion, but the committee add that further improvement of the internal combustion engine might materially alter matters. The high speed is not demanded for emigrant ships, and it is thought would do little to increase the volume of first-class passenger traffic. The conditions are, of course, very different from those ruling in the Atlantic service. The population of North America is about 115 millions and that of Australia about 5½ millions.

It is added, moreover, that for business purposes the cable is being increasingly used, and this reduces the need for a high-speed mail service. What the latter is essential for, is for the conveyance of shipping documents, which ought to arrive in Australia before the cargo sent by the first ship that sailed after the preceding mail left. This requirement is apparently met for the present, but it may be added that as larger and larger boats are being built, there is a tendency for the speed of cargo carriers to increase, and the need for an accelerated mail may thus become imperative.

Economically, this is impossible without a subsidy, but by a reversion to a South Italian port for shipping the mails, by faster running on the Australian railways, and by increasing sea speeds between Suez and Fremantle to an average of 16 knots, the committee think that it might be possible, at no inordinate cost, to reduce the present time of transit for the mails between London and Melbourne by about five days. To gain an additional two days would require 18-knot steamers, and this would necessitate a large increase in the subsidies.

An attractive alternative, which the committee hold should be further investigated before coming to a final decision, is the establishment of an air service between London and Egypt, which, combined with a 16-knot sea service between Suez and Fremantle and faster railway running in Australia, would reduce the time of transit between London and Melbourne by six or seven days. There are obvious subsidiary advantages attending such an arrangement.

* Report on the economic size and speed of vessels trading between the United Kingdom and Australia and on the subsidies necessary to maintain speeds in excess of the economic speed. London: H.M. Stationary Office. Cmd. 1917. [Price 6d.]

## THE RIGHTS OF TRADERS IN COMBINATION.

The case of Reynolds *v.* The Shipping Federation and the National Sailors' and Firemen's Union, in which judgment was given by Mr. Justice Sargant on July 27, raised an interesting question as to the rights of persons acting in combination. The plaintiff complained that the Federation and the union had prevented him from obtaining employment as a greaser in the steamship Demosthenes because he was not in possession of a card known as the P.C. 5, supplied by the National Maritime Board to the union for issue by them to the members of the union. The Board was originally constituted by the Ministry of Shipping in 1917 for the purposes of enabling shipowners to obtain crews without difficulty, of removing causes of friction, and of enabling questions between employers and employed to be dealt with promptly and effectively. The representatives of the Board on the employers' side were elected by the Shipping Federation and the Employers' Association of the Port of Liverpool, while the representatives of the employees were elected by the unions, the sailors and firemen's panel being elected by the defendants, the National Sailors' and Firemen's Union. The Stewards' Union withdrew from the Board after an unsuccessful strike in 1921, and amalgamated with a small sailors' and firemen's union at Southampton as the Amalgamated Marine Workers' Union. The plaintiff was a member of that union. There had been keen rivalry between it and the National Sailors' and Firemen's Union.

The Shipping Federation recognised that if any considerable portion of the men employed in their ships were members of the Amalgamated Marine Workers' Union there would be a virtual end of the system of collective bargaining, and the Federation made an agreement with the National Union, under which the supply of men to the ships of the members of the Federation should take place through the union. It was part of the arrangement that every man, before he was engaged, should produce a card

which should be stamped by the union and afterwards stamped by the federation. It was not actually stated that every man engaged should belong to the National Union, but it was assumed that only men would be sent who would be bound through their representatives on the National Maritime Board. The plaintiff had tried to obtain employment on the ss. Demosthenes, but had been unable to do so because he refused to join the National Union. The question was whether the arrangement between the federation and the National Union was such an invasion of his *prima facie* right to seek and obtain employment as to amount to a legal wrong.

His lordship held that the agreement or combination was not against a particular individual, but operated merely to exclude such individuals as might not from time to time satisfy a qualification which was within the reach of anyone who desired employment. Further, the motive of the exclusion was not a malicious desire to inflict loss on any individual or class of individuals, but a desire to advance the business interests of employers and employed alike by securing and obtaining the advantages of collective bargaining. His lordship thought the principles laid down in the Mogul steamship case in 1892 were fatal to the plaintiff's claim. In that case a number of shipowners had combined to make it impossible for the ss. Mogul to compete with their ships in Chinese ports. For this purpose they offered a special discount to exporters who used their ships alone; they arranged to send steamers of their own to meet any competing vessels sent to Hankow, and to underbid them for freight, and they forbade their agents, on pain of dismissal, to act as agents for their competitors. The owners of the competing vessel sued them for damages on the ground that they had conspired to prevent their vessel from being employed by shipowners in the Chinese ports, for the carrying of cargoes. The House of Lords held that the Associated Shipowners had done nothing unlawful. They had merely offered reduced rates to persons who would deal exclusively with them, and it was not unreasonable that they should have prohibited their agents from acting for their competitors. Everything that was done was in the way of legitimate competition for the legitimate furtherance of the association's interests, and no legal wrong had been done to the owners of the competing vessel.

The great point is that although the result of the arrangement between the Shipping Federation and the National Sailors' and Firemen's Union was to make it impossible for the plaintiff to obtain employment in any of the vessels controlled by the federation unless he became a member of the union, the arrangement between the federation and the union was merely for the furtherance of their own legitimate interests, and they were not seeking to attain their ends by any unlawful means such as intimidation, threats or violence.

## PROGRESS IN MARINE PROPULSION.

A SHORT article dealing with the present and future of marine engineering which recently appeared in *Nature* should be of interest to those who are concerned in the subject. At the outset it is stated the world's mercantile tonnage of ships over 100 tons is now 61 millions or approximately 14 millions above the corresponding figures for 1914, but the disturbance of economic conditions caused by the war has resulted in a serious diminution of maritime traffic and a consequent slackness in the employment of ships. Circumstances have thus compelled shipowners and designers to inquire more thoroughly than hitherto into the most economical type of ship and its propelling machinery for the purposes of future building. The writer then proceeds to review progress in propelling machinery, remarking that at the present time 51 millions of tonnage are fitted with the coal-fired boiler and reciprocating steam engines. Passing next to the steam turbine it is stated marine installations of this type aggregate 50 millions of horse-power, although presumably the greater portion of this total is fitted in the warships of the nations. The geared turbine and the difficulties therein encountered are next mentioned before passing to a consideration of the improvements which have resulted from the use of the oil-fired boiler. Referring to the economical advantages of the latter it is stated the duty formerly obtained from 1 lb. of coal is now served by ¾ lb. of oil, and that the greater ease of fuelling compared with bunkering a ship involves a great saving in time and labour. In the case of the Majestic, 6 hours is the time required for filling the fuel tanks, whereas previously 4½ days were necessary to fill the bunkers.

Diesel engines for marine purposes are next considered, and it is remarked progress in the adoption of these on shipboard was at first slow, as although such engines were introduced in 1893 it was not until seventeen years later, the first Diesel-engined ship crossed the Atlantic. Since then, progress has been rapid, for whereas in 1914 the number of ships so fitted was 297 it is now 1,620, with a total horse-power of 1⅛ millions. The writer expresses the opinion oil will gradually displace coal on shipboard, a somewhat gloomy prognostication for the Welsh coal industry.

In the concluding paragraph of the article, and as an illustration of the progress made, it is stated that fifty years ago the sea transport of 100 tons of cargo for a distance of 1 mile required the expenditure of 18 lb. to 20 lb. of coal, whilst at the present time 1½ lb. to 2 lb. of oil are sufficient for the same purpose. Such figures are difficult to obtain, but are eloquent of half a century's progress, and should be a source of satisfaction to all those who have been or are at the present engaged in the problems of sea transport.

The article is wholly devoted to the consideration of different types of propelling machinery, and a reader will probably, and very naturally, conclude the remarkable progress, as illustrated by the figures just given, is entirely due to the improvements in machinery. Such a conclusion would, however, be erroneous and misleading, for there are many other factors, not referred to in the article, which have exercised an appreciable and beneficial influence on the economics of sea transport, and have contributed in no small degree to the result. It is, moreover, very important these should not be overlooked when such comparisons are attempted and endeavours made to analyse them. In the following remarks the main factors contributing to the progress in economical propulsion are briefly discussed.

The issue of ENGINEERING dated April 18, 1873, includes an account of the 6 hours' full power trial of H.M.S. Devastation, just then completed, and during which the engines developed 5,700 i.h.p., the coal used per indicated horse-power being 2·9 lb. The ship had been under construction for some years, and her engines were of the simple horizontal trunk type, the boiler pressure being 30 lb. per square inch, and the maximum revolutions of the engines 72 per minute. Horizontal compound engines using higher pressure steam had been introduced into the Navy a few years previously, the first ship so fitted being the Briton, which had passed through her trials in 1871. She was followed by other vessels similarly fitted, the power of the engines being, however, generally less than those of the Devastation. The indicated horse-power on the Briton's trials was 2,150, the boiler pressure 64 lb. per square inch, and the revolutions 95 per minute.

Many of the pages of *Naval Science*, a quarterly edited by the late Sir Edward Reed, and published during the period 1871 to 1875, are devoted to a discussion as to the type of engine most suitable for naval purposes. Some experts were against the introduction of compound engines and high-pressure steam—60 lb. as compared with 30 lb. then generally in use—for they argued serious consequences, probably resulting in the total loss of a vessel, were involved, if a projectile pierced the boiler shell, whereas with the lower pressure the vessel would sustain little injury. Fortunately, those who advocated compound engines and higher pressures were strongly supported by the decision of the Committee on Designs of Warships which had just then completed its labours. In the course of these discussions interesting information as to the coal consumption for the engines then in use in ships is given. In five warships whose engine trials took place between 1869 and 1873 and which were fitted with simple horizontal engines working with a steam pressure of 25 lb. to 30 lb., the indicated horse-power for the five ships varying between 2,000 and 8,000, the average coal consumption was 2·9 lb. per indicated horse-power per hour, the results ranging between 2·8 lb. and 3·1 lb. For five ships fitted with compound engines working at a pressure of 55 lb. to 60 lb., and whose trials took place between 1870 and 1873, the average consumption was 2·4 lb., the variation being from 2 to 2·6. The figures for the 10 ships were all obtained on full power trials and not at the most economical speeds. Two other naval vessels are mentioned, the Swinger and the Goshawk, in which the coal consumption at full power was 2·6 lb. and at low powers 2·1, the steam pressure in both ships being 50 lb. Two merchant ships are also referred to, the Circassian of the Allen Line, fitted with simple engines and Corliss valve gear, and in which the coal consumption was 2¼ lb.; and the Elbe, for which the figure of 2·2 lb. is reported. An interesting note that the White Star liner Britannic, then building, was being fitted with vertical compound engines, also appears. This type of engine was also fitted in the naval vessels of the Cyclops class just then completed.

From the figures given in the foregoing it may be concluded the coal required for the best type of engines of fifty years ago was not more than 2¼ lb. per indicated horse-power per hour at economical speeds, a figure which should be used for comparison with that of the best of present engines in arriving at any figures relating to the economics of sea transport.

The oil consumption in the internal-combustion engine of the Diesel type is about 0·45 lb. per brake horse-power, or since the indicated horse-power is about one-third more than the brake, about 0·34 per indicated horse-power, giving a ratio of weights fifty years ago to the present as 6½ is to 1.

It is to be remarked, however, that so far as the economical propulsion of the ship is concerned the advantage indicated by this ratio is not fully secured. As a matter of experience, it is found the propulsive coefficient of the ship, that is the ratio between the effective and the brake horse-power in oil-engined ships, has practically the same value as that of effective to indicated horse-power in reciprocating steam-engined ships, and not as might have been expected one-third more, the excess of indicated over brake horse-power. So far as economical sea transport is concerned the ratio of weight of coal to that of oil is very nearly 5 to 1, in place of the 10 or 12 to 1 mentioned in the article under consideration.

A reduction in the fuel required per unit of power is accompanied by a corresponding decrease in the total weight of fuel for a given voyage, and an increase in the weight of cargo which can be carried. This gain is discounted to a very great degree by the weight of the oil engines, which are even heavier per unit power than the steam engines of 1873. A recent statement in a periodical devoted to internal combustion engines shows that the cost of transport per unit weight of cargo is 7 per cent. less in the oil-engined ship than in the same fitted with steam reciprocating engines, and although the cost with the latter is less than with the engines of 1873 the difference is not a great one.

It is now necessary to refer to those other factors which have been introduced during the past fifty years and which have effected economical transport by sea. The ships of 1873 were built of iron, and it was not until a few years later steel came into general use for the structure of vessels, thereby decreasing the weight of hull and increasing the weight of cargo to a corresponding extent, and also decreasing the cost of transport per unit weight. The late Sir William White estimated that in a vessel of 5,000 tons displacement the substitution of steel for iron increased the cargo carried by 3 per cent., and in a vessel of 12,500 tons 17 per cent. Another feature which has led to improved economy is the greater size of ships now as compared with those of 1873. The Allen liner Circassian, which has been referred to, was of a gross tonnage of 3,700. The smallest ship of the same company at the present time is the Sicilian, which is of 7,400 gross tonnage. She was built in 1899, almost at the middle of the half-century. Other and later vessels

of the same line are over 10,000 gross tonnage. It is an easily demonstrated fact that with an augmentation in size a greater percentage of the displacement can be allocated to cargo, and the indicated horse-power per ton of displacement for the same speed is sensibly reduced. Both differences lead to more economical transport. Naval architects have generally taken the initiative in suggesting larger vessels, and have urged and encouraged the marine engineers to design and proceed with the construction of the larger and more powerful engines which were necessary.

The most striking improvement which has been effected in economical transport by sea during the past fifty years must, however, be attributed to the nearly complete knowledge which has been gained on the subjects of the resistance and propulsion of ships, and almost wholly to the researches and experiments of Mr. W. Froude and his son, Mr. R. E. Froude. Fifty years ago very little was known as to the laws of ship resistance, and even less of those of the twin subject, propulsion. Naval architects were using the very approximate methods of the Admiralty coefficients for estimating resistance, and for arriving at the characteristics of propellers the procedure was even more crude. Working with the Admiralty coefficient for resistance, which involved the immersed midship area, the latter was made the minimum practicable in the hope the resistance would be reduced thereby. The form of the ship was sacrificed to the minimum midship area, a procedure which later knowledge proved to be altogether incorrect.

Mr. W. Froude's classical experiments with the Greyhound were carried out in 1871, and in 1873 the results of his analysis of the results were published, followed a year afterwards by those of his experiments on surface friction. This was the first step in the elucidation of the problem of ship resistance, and it was followed by others which finally placed the whole subject on a scientific basis, by which the effect of dimensions and form of a ship on its resistance can now be very accurately determined. It is difficult perhaps to estimate the quantitative effect of these researches and experiments on the economy of marine transportation. As an illustration of the progress made, it can be stated the resistance of the Devastation of 1873, a ship of 9,000 tons, was the same at 16 knots as that of a ship of the present day of 19,000 tons.

The experiments on resistance of ships were supplemented by others on screw propellers, and the analyses of these, together with those carried out later by Mr. R. E. Froude at the Admiralty Experiment Tank at Haslar, have resulted in an almost complete knowledge of the phenomena attending propulsion by screws, and rendered the design of screw propellers to suit required ship conditions an interesting and not very difficult problem. Here, again, it is difficult to assess the gain in economical propulsion which has been effected, but it has been very appreciable.

The whole of the results of the work of the two Froudes was published as soon as they became available, and the military and mercantile navies, and also the people of the nations, have greatly benefited. From the nature of the case the accumulation of this knowledge has been gradual, albeit none the less effective, but as it has been less spectacular, less obtrusive and less commercial than the improvements in the efficiency of the older types of propelling machinery, or in the introduction of new types, it is very liable to be forgotten and overlooked when comparisons, such as those referred to, are being instituted.

There are other and minor differences, but it is not unreasonable to conclude that in the remarkable progress which has been effected in the economics of marine transport during the past half-century, as illustrated by the figures given in the article in *Nature*, about one-half is due to improvements in the propelling apparatus, and the remhinder to modifications in the material of the structure, dimensions, and forms of the ships themselves. At the basis of all lies a greater scientific knowledge of the factors entering into the problems, and also a more complete co-ordination and co-operation of the work of the marine engineer and the naval architect.

# LITERATURE.

*Indian Engineering: Relating to Irrigation, Water Supply of Towns, Roads, and Buildings.* By William Lumisden Strange, M.Inst.C.E., Chief Engineer in Sind (retired). London: George Routledge and Sons, Limited. [Price 12*s.* 6*d.* net.]

The real test of an engineer is to make the best and most economic use of the material available, and to adopt the most efficient and economic methods of construction consistent with the class of labour available, and conditions obtaining in the country in which his work lies; but to the young engineer about to start his career in India, the title of Mr. Strange's book is apt to be misleading, as he will search in vain for a description of the materials available, the methods of construction, and labour conditions in our great Empire in the East.

The book, as stated by the author, is mainly concerned with principles governing design and construction, and deals chiefly with the general principles of irrigation works in India, and as such will be a useful addition to the library of the young engineer entering the Indian Public Works Department.

Water is so essential to the life and welfare of the millions of the people of India that only the State should undertake its control. By long-established law the control of water in rivers and streams is vested in the State, and as pointed out by the author it will be "a bad day" for India if she ever takes a retrogade step of making public water a private possession. This fact is often not recognised by the administrators of the Empire, who sometimes are influenced by the law and precedents of this country. A great deal of unnecessary litigation would be avoided if a stronger and firmer attitude regarding the State's right of control of public water is adopted. Except in the case of wells, it is undesirable that the State should assist private enterprise in irrigation works. The design, construction and maintenance of irrigation works in India should be a national undertaking. Irrigation works in India are a class of engineering works *per se*, and success is only obtained by long experience, meticulous care, and devotion to duty.

In the study of Nature as in all scientific methods the use of both inductive and deductive reasoning assisted by imagination is essential in discovering the causes of phenomena, and as pointed out by the author, it is better in order to secure continuity and similarity of observation to have a settled organisation for the hydrographic survey of the country, where all questions relating to irrigation can be scientifically dealt with, and to utilise in it the services of those who have shown a decided bent for carrying out purely scientific work, than to leave this "highly scientific work" to individual enthusiasts. Considering that agriculture is the great backbone of India, and "Irrigation" one of the greatest blessings that can be conferred on the country, one is at a loss to understand why a hydrographic branch of the Indian Public Works Department has not been constituted.

In financial matters relating to large irrigation projects the rules laid down by the Finance Department of the Government of India are sound, and it will, to quote the author's own words, be "a bad day" for India if they are departed from. They are a considerable deterrent against "pet schemes" being sanctioned based on visionary "Indirect receipts."

As pointed out by the author, in the distribution of water the engineer should work in conjunction with the Department of Agriculture, but he will be well advised to study local custom and village tradition, which are based on the observations of successes and failures of centuries.

The quantity of water necessary for irrigating a tract of land varies considerably and depends on the crop grown, rainfall, nature of soil, depth of the ground water, plane of saturation, temperature, and method of cultivation adopted. The general principles are the more manure and labour employed in cultivating the land the less the supply of water necessary; as exemplified in well irrigation, where the plots irrigated are intensively cultivated, and no more water than is necessary is raised.

Rainfall and other data are treated in a very general manner. Mr. Strange ascribes the decrease of rainfall in certain countries, as believed, to be due to deforestation; this theory is still a disputed question, and one may well ask the reason for the rainless track stretching from the Sahara in North Africa across Arabia, and Persia to the Gobi. Also it is not always that the sheltered, or leeward side of mountainous areas receives the heaviest downpour; the elevation and slope of the mountains are important factors to be taken into consideration.

The chapters on floods and flood discharge capacity treat of general principles and should be read in conjunction with the chapter on full supply and "High flood levels." In the numerous tanks scattered over the Madras Presidency where frequent inspection of the staff in charge of surplus works is not possible, a solid weir is the safest work for the disposal of flood water. In the chapter on yield of catchment no mention is made of the mass curves of yield and demand as laid down by Dr. Deacon.

The subjects treated by Mr. Strange are so numerous that he has not done full justice to his knowledge and experience. More detail and explanatory diagrams would have made his book more useful. The chapters on percolation and hydraulic gradient should be treated more fully, but it may be pointed out that the conditions laid down are for works in a porous soil which do not obtain in the heavy clay deltas of South Indian Rivers.

The "pipe adit" well is a new departure, and its working will be watched by those interested in well irrigation. The construction does not seem simple, or suitable to the means and appliances of the ordinary cultivator.

All officers of the Indian Public Works Department will agree with Mr. Strange in the necessity for a carefully-compiled history of important works carried out in India. One method is to collect all printed Government Orders on a work and bind them periodically, but details of construction and results of experiments, and observations made during the work, are not recorded, and in course of time are lost sight of. A central bureau to collect, analyse and publish the results of experiments and observations has been a long-felt want and Mr. Strange's suggested Hydrographic Branch of the Indian Public Works Department indicates how this want can be supplied.

*Machine Tools and Their Operation.* By Fred. H. Colvin and Frank A. Stanley. Vol. I. *Lathes, Drills and Drilling, Hand and Automatic Screw Machines, Screw Machine Tools and Boring.* Vol. II. *Planers, Shapers, Slotters, Broaching, Milling, Gear Cutting and Grinding.* London: McGraw-Hill Publishing Company, Limited. [Price, each vol., 20*s.* net.]

This work, in two parts, contained in separate volumes, is a compilation from the *American Machinist*. It is a useful book for reference. A very large selection of tables relating to the operation of machines can be readily consulted by tool designers and foremen. The condensed treatment of the subjects selected covers a wide range of practice. The illustrations are numerous. Blemishes are: That while some matters are handled at great length, disproportioned to the size of the volumes, others of equal import have scanty treatment. The illustrations are seldom sectional views, perspectives predominate. The number of photographs is greatly out of proportion to the outline drawings. Many are very poor, and their obscurity is tantalising. The machine tools illustrated are not shown with drawings, but with outline perspectives, or photographs, with reference letters, or numbers to indicate the different details, so that no internal sections are included. The section on gear-cutting is bald. The methods of generation are not described. No hint is given of the latest generation of bevel gears, nor of the rack cutter types for spur gears, beyond the strange statement respecting the Sunderland and the Maag machines, that "neither are as yet in common use." The subject occupies only 34 pages, 12 of which are devoted to tables. On the other hand, in vol. i the subject of screw machines fills 178 pages, out of a total of 337 pages. And yet the regular turret lathes are omitted. These and other facts of a similar character would seem to indicate a rather random selection of such material as happened to be most readily available, instead of a well-balanced scheme.

The volumes are of slight value as a presentation

of the construction of machine tools, since they are not illustrated with detailed drawings, neither are the numerous variations in designs even mentioned. Their chief value lies in the wealth of data and tables collected from various sources, and arranged in connection with the work of the different machines. These data are a safe guide to the practice on which they have been based. They cover an extensive field of dimensions, proportions, speeds, feeds, steels, grinding wheels, &c.

The subject selected is too extensive to be adequately treated. Apparently the present time of high specialisation requires monographs rather than all-embracing volumes, so that each great group of machine tools, with the operations performed on them, might appropriate a separate volume that should embrace everything which can be usefully said on the subject, and answer every query that is likely to arise. The materials are abundant. The difficulty from the point of view of the publisher is, that their utility may not be long-lived, because practice now advances with so rapid strides that the best information of to-day will probably be becoming antiquated a decade hence.

## BOOKS RECEIVED.

*Statistical Bibliography in Relation to the Growth of Modern Civilisation: Two Lectures Delivered in the University of Cambridge, May*, 1922. By E. WYNDHAM HULME, B.A. London: Butler and Tanner, Grafton and Co. [Price 6*s.* net.]

*L'Electro-Sidérurgie. Fabrication de L'Acier au Creuset.* By CH. CLAUSEL DE COUSSERGUES. Paris: J. B. Bailliere et fils. [Price 40 francs.]

*Ministry of Public Works, Egypt. Index to Annual Reports, Irrigation Department.* 1884–1920. Cairo: Government Press. [Price P.T. 10.]

*The Birmingham Exchange. Directory of Members, Subscribers and Representatives*, 1923. Birmingham: Birmingham Exchange. [Price 2*s.* 6*d.*]

*Electro-Chemistry Related to Engineering.* By W. R. COOPER, M.A., B.Sc. London: Constable and Co., Limited. [Price 12*s.* 6*d.* net.]

*Wärmewirtschaftsfragen.* By L. LITINSKY. Leipzig: Otto Spamer. [Price 3*s.* 9*d.*]

*Aeronautical Research Committee.* Reports and Memoranda No. 800. *Report of the Airship Stressing Panel.* London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 2*s.* 6*d.* net.]

*Aeronautical Research Committee.* Reports and Memoranda No. 813. *Experiments on Rigid Airship R.32.* Part III. *Measurements of Resistance and Air Speed.* By J. R. PANNELL and others. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*s.* 6*d.* net, post free 1*s.* 7*d.*]

*Les Economies de Combustibles, Conduite Rationelle des Foyers.* By PIERRE APFELL. Paris: Gauthier-Villars and Cie. [Price 17 francs.]

*L'Eclairage. Solutions Modernes des Problèmes D'Eclairage Industriel.* By E. DARMOIS. Paris: Gauthier-Villars and Cie. [Price 15 francs.]

*Die Lehren der Explosionskatastrophe in Oppau für das Bauwesen.* By Dipl.-Ing. H. GOEBEL and Dr. Ing. E. PROBST. Berlin: Julius Springer. [Price 5*s.*]

*Association Suisse de Propriétaires de Chaudières a Vapeur. 54 ème Rapport Annuel*, 1922. St. Gall: Zollikofer and Cie.

*Hydraulics for Engineers and Engineering Students.* By Professor F. C. LEA, D.Sc., M.Inst.C.E. Fourth edition. London: Edward Arnold and Co. [Price 18*s.* net.]

*Engineering Non-Ferrous Metals and Alloys.* By LESLIE AITCHISON, D.Met., B.Sc., and WILLIAM R. BARCLAY. London: Henry Frowde and Hodder and Stoughton. [Price 21*s.* net.]

*Machine Drawing. A Text and Problem Book for Technical Students and Draughtsmen.* By CARL L. SVENSEN, M.E. New York: D. Van Nostrand Company. London: Scott, Greenwood and Co. [Price 12*s.* 6*d.* net.]

*Structural Members and Connections.* Edited by GEORGE A. HOOL and W. S. KINNE. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 30*s.* net.]

*Foundations, Abutments and Footings.* Edited by GEORGE A. HOOL and W. S. KINNE. London: McGraw-Hill Publishing Company, Limited. [Price 20*s.* net.]

*Principles of Chemical Engineering.* By WILLIAM H. WALKER and others. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 25*s.* net.]

*Les Isotopes.* By A. DAMIENS. Paris: Gauthier-Villars and Cie. [Price 12 francs.]

*Canada, Department of Mines. Mines Research. Summary Report of Investigations made by the Mines Branch during the Calendar Year ending December 31, 1921.* Ottawa: F. A. Acland.

*Industrial Furnaces.* Vol. I. By W. TRINKS. New York: John Wiley and Sons, Inc.: London: Chapman and Hall, Limited. [Price 22*s.* 6*d.* net.]

*Calculations in Heating and Ventilation.* By G. S. COLEMAN, D.Sc. London: Longmans, Green and Co. [Price 15*s.* net.]

*The Journal of the Institute of Metals.* Vol. XXIX., 1923. Edited by G. SHAW SCOTT, M.Sc. London: Institute of Metals. [Price 31*s.* 6*d.* net.]

## INDUSTRIAL NOTES.

THE Industrial Group of the House of Commons addressed on July 24 a letter to the Prime Minister, calling his attention to the present state of unemployment in this country, and adding that unless very drastic measures were taken immediately, a fourth winter of unemployment, with not less than 1,500,000 unemployed, must occur. The results of this on the *morale* of the British worker would be disastrous; the worker's efficiency must be irretrievably damaged. There were, moreover, 100,000 ex-service men trainees for whom the promised employment cannot at the present time be found. Large numbers of skilled workmen were emigrating to America, and any large revival of trade would be accompanied by a shortage of skilled labour. The country could not look to its foreign trade to provide a solution, though the Industrial Group felt that something might be done by the extension of the export credits scheme, for example, to Roumania, for locomotives and bridges, and to Russia, where large contracts for power-house construction and equipment might be secured if certain financial facilities were afforded to British firms who were now willing to take their fair share of the risk. Further, immediate information should be obtained from the Dominions and Crown Colonies as to any large schemes held up for lack of funds. The problem by its very nature demanded for its solution a policy of employment rather than an unemployment policy. If a definite policy of productive employment were formulated, unemployment would look after itself. The letter then stated a concrete policy of employment. This covered the electrification of several sections of our railways, the extension of tube railways, the reconditioning of railways, the development of canals and inland waterways, the construction of a lower Thames Tunnel, of a floating dock at Grimsby, the carrying out of the Port of London Authority's dock extension scheme, and authorising approved municipal schemes which were definitely revenue producing. The Industrial Group emphasised the paramount necessity for immediate action, and even if the policy necessitated the payment by Government of interest for several years on the capital involved, the sum would be very small in comparison with the unemployment dole and the relief granted by the guardians. We refer to this matter in a leader in this issue.

Speaking in Parliament last week, Sir Philip Lloyd-Greame, President of the Board of Trade, said that the Government had sent a letter to all local authorities in the country informing them that if they would put in hand schemes of a revenue-producing kind, works which would involve the placing of engineering orders and orders for material in those industries which most needed orders of that kind to-day, the Government would come to their help, and make advances of 50 per cent. of the interest charges for fifteen years in cases of loans. The Government were also prepared to do the same thing for public companies carrying on the same class of work who were prepared to accept the conditions, both as regards repayment or as to the limitation of dividends during the time that the loan or advances from the Government were in operation. They also proposed to raise these questions at the Imperial Economic Conference. Financial co-operation was one of the subjects included in the agenda of that Conference, which they were anxious to discuss with the Dominions. A telegram had been sent to the Prime Ministers of the Dominions saying that the Government were anxious to discuss this matter, and, without excluding from consideration any form of assistance, the Government considered that a guarantee of interest or the advance of part interest for a limited period was likely to prove the most useful method. The same principle would apply in regard to the Crown Colonies, and they would go forward at the Imperial Conference in dealing with Crown Colony developments with the firm intention of helping sound schemes which would anticipate development, mean the placing of orders in this country, and draw settlers from here to the Dominions. The responsibility for these matters rested not only on the Government, but on every one in the country. The policy of the Government could not save the country or restore its trade or place employment on a stable and sound basis unless employers and employed were ready to pull together and see the country through.

Last Sunday the dockers at Hull decided to return to work on the following day (last Monday), following a vote which showed a majority for ending the strike. They resume work at 10*s.* per day, under the terms of the national agreement. At the time of writing the strike at the London docks was still running its course, but the men were gradually returning to work. The strike has done, and is continuing to do, a vast amount of harm, the very least of which is the diversion of ships from Hull and London to other ports of the country.

Sir Frederick W. Lewis, Bart., presiding at the thirty-second annual general meeting of Messrs. Furness, Withy and Co., Limited, held last week, dealt incidentally in his report with the dock strike, and said that even after the reduction of 1*s.* per day which had duly been agreed upon, the rate of pay of the dockers would be 10*s.* a day of 8 hours, as compared with 5*s.* 10*d.* a day of 10 hours in 1914, so that for the same number of hours' work the dockers would receive 114 per cent. more pay than in 1914, as compared with an increase of 69 per cent. in the cost of living. It was, of course, a lamentable fact, which, he was sure, no one regretted more than the employers themselves, that the dockers' employment was of a casual nature. This also applied to the trading of ships, as nothing could be more casual than the employment of shipping at the present time. The shipping laid up at the 36 principal ports of the United Kingdom on July 1 amounted to 712,000 net tons, as compared with 546,555 net tons on April 1 last. Unless there were an unforeseen improvement, he very much feared the figure would be still further increased.

In the matter of the facilities, or lack of facilities for loading at the British ports, Sir Frederick W. Lewis gave a striking illustration. One of his company's vessels loaded some 8,800 tons of coal in a United States port between her arrival on Sunday morning and her sailing on Tuesday evening. At about the same time a vessel in Cardiff, after having waited nine days to get into a berth, occupied eight days in loading and bunkering and only sailed on the ninth day—three days as against eighteen.

A ballot was taken recently amongst the members of the Boilermakers' Society, on the question of levying from each member 1*s.* per week for 10 weeks, in connection with the lock-out. The ballot showed a majority of 3 to 1 in favour of the proposal. The figures of the ballot are not stated. It has further been decided that the lock-out benefit is to be increased from 12*s.* to 15*s.* per week. A circular issued by the Boilermakers' Society states that the members who are working have decided to pay 10*s.* per man, and in addition have accepted the proposal for voluntary loans. The circular adds that certain federated firms have already recognised the injustice and stupidity of the lock-out, have left the Employers' Federation and re-employed members of the Boilermakers' Society. To this, the federation has replied that the circular is more in the nature of an exhortation to the members than a statement of the facts, but on facts it is inaccurate. Over two months ago one firm—situated in an isolated district, and employing only a very small number of boilermakers—withdrew their notices, on the members of the Boilermakers' Society employed with them arranging to return to work under the full terms of the agreement. Apart from this, the society's assertion that certain federated firms have re-employed boilermakers is without any foundation, nor is there any truth in their further assertions that other firms have appealed to the federation to accept one of their alternatives. While the Boilermakers' Society has been invoking the aid of outside agencies, their own trades federation has expelled them for refusing to honour an agreement which they entered into on behalf of all their members—including the Boilermakers' Society—with the Employers' Federation.

Since the note in our last week's issue meetings of the various unions have been held to consider further the railway shopmen difficulty, particularly in connection with the London and North-Eastern Railway. The craft unions are still in disagreement with the National Union of Railwaymen. The notice of the latter union calling for a strike to commence on Thursday (yesterday) was withdrawn on Tuesday, the Executive of the union having decided to accept the proposal made by the railway of arbitration by the Industrial Court. Sir Montague Barlow, the Minister of Labour, is taking the matter in hand.

NEW GENERAL POST OFFICE, SINGAPORE.—Messrs. Edmond Coignet, Limited, 125, Gower-street, W.C. 1, inform us that their scheme for the new G.P.O., Singapore, has been accepted by the Crown Agents for the Colonies, who have appointed that firm to prepare the working drawings and all the necessary particulars for the construction. The scheme for the reinforced concrete was competed for several months ago by various designers, and the actual work will probably be put up for tender amongst local contractors. The general architectural design is by Major P. H. Keys, D.S.O., F.R.I.B.A., Singapore. The new building will be one of the finest in the Straits Settlements. It stands in a triangular site. The principal façade is 400 ft. long, two being about 300 ft. each. All the façades are decorated by massive columns and elaborate cornices. The building will be six storeys high with a flat roof, and the foundations are composed of a reinforced concrete raft.

## TESTS OF AN ERSTE BRUNNER BACK-PRESSURE STEAM TURBINE.

WE have received from Professor D. Dresden, of Ten Hovestraat 75, Den Haag, Holland, the following figures which he recorded in a test he recently made of a new type Erste Brunner steam turbine :—

| Test number | 1 | 2 | 2a | 3 | 4 |
|---|---|---|---|---|---|
| Length of test in minutes | 92·75 | 75·2 | 50·9 | 58·9 | 60·0 |
| Average load in kilowatts | 2,548 | 1,013 | 1,005 | 2,097 | 0 |
| Effective steam pressure before turbine, lb. per sq. in. | 182 | 180 | 184 | 172 | 154 |
| (1) Effective steam pressure behind regulating valve, lb. per sq. in. | 178 | 111 | 109 | 163 | 33 |
| (1) Total temperature behind regulating valve, deg. F. | 740 | 714 | 728 | 672 | 592 |
| (2) Effective pressure behind H.P. part, lb. per sq. in. | 64·0 | 31·5 | 31·5 | 56·0 | 11·7 |
| (2) Total temperature behind H.P. part, deg. F. | 549 | 502 | 518 | 480 | 466 |
| (3) Effective pressure in outlet, lb. per sq. in. | 7·3 | 7·3 | 7·3 | 7·3 | 7·3 |
| (3) Total temperature in outlet, deg. F. | 314 | 371 | 381 | 288 | 430 |
| Total quantity of condensed steam, lb. | 77,000 | 33,000 | 22,000 | 44,000 | 9,400 |
| Steam consumption in lb. per kilowatt-hour | 19·6 | 26·1 | 25·9 | 21·4 | — |
| Total heat in steam in B.Th.U. per lb.— | | | | | |
| Behind regulating valve | 1,392 | 1,383 | 1,390 | 1,360 | 1,328 |
| Behind H.P. part | 1,300 | 1,285 | 1,291 | 1,270 | 1,268 |
| In outlet | 1,205 | 1,225 | 1,230 | 1,185 | 1,251 |
| Total heat after adiabatic expansion from condition— | | | | | |
| (1) Down to pressure (2) | 1,288 | 1,265 | 1,275 | 1,527 | 1,262 |
| (1) Down to pressure (3) | 1,168 | 1,195 | 1,206 | 1,156 | 1,243 |
| (2) Down to pressure (3) | 1,181 | 1,210 | 1,218 | 1,167 | 1,250 |
| Efficiency calculated from steam consumption, per cent. | 82·16 | 77·4 | 78·4 | 83·2 | — |
| Efficiency calculated from temperatures without correction for radiation losses— | | | | | |
| H.P. part | 84·7 | 86·0 | 85·8 | 87·0 | 90·0 |
| I.P. part | 83·4 | 82·0 | 84·4 | 83·0 | 92·0 |
| Total | 85·7 | 85·5 | 86·7 | 86·0 | 90·6 |
| Heat loss (calculated) by radiation in B.Th.U. per lb.— | | | | | |
| H.P. part | 1·68 | 3·15 | 3·15 | 1·84 | 6·75 |
| I.P. part | 1·05 | 1·98 | 1·98 | 1·17 | 5·95 |
| Efficiency calculated from temperatures corrected for radiation losses— | | | | | |
| H.P. part | 83·0 | 83·2 | 83·0 | 85·5 | 80·2 |
| I.P. part | 82·5 | 79·0 | 81·5 | 81·5 | 59·0 |
| Total | 84·0 | 82·5 | 84·3 | 84·5 | 75·5 |
| Mechanical losses calculated from efficiencies, in kilowatts | 55·0 | 62·5 | 70·0 | 35·0 | — |

It should be noted that the efficiencies stated are efficiency ratios, which are well known to constitute a very unfair means of comparing the performances of turbines working under different conditions. This is well shown in the tabulated figures where the overall efficiency of the turbine is given as higher than that of either of the component elements. The true basis of comparison is the hydraulic efficiency, which is equal to the efficiency ratio divided by the reheat factor. As the steam was still superheated on discharge this reheat factor was large, and hence it follows that the overall efficiency ratio given as 84 per cent. near the bottom of column 1 corresponds to a real internal hydraulic efficiency of about $\frac{84 \cdot 0}{107 \cdot 5} = 78$ per cent. This may be compared with the exactly corresponding figure of 80·5 per cent. recorded at Walsall and the 83 per cent. hydraulic efficiency of the Interborough turbine described in the Journal of the American Society of Mechanical Engineers in June, 1916. It will be evident, therefore, that without further particulars it is impossible to form any judgment as to the importance of the tests made by Professor Dresden.

At Walsall the ratio of blade speed to steam speed is about 0·67, and in normal standard reaction turbine practice, an hydraulic efficiency of 78 per cent. should be realised with a ratio of blade speed to steam speed of less than 0·6. It is possible that the new turbine reaches the efficiency stated, with a lower value of this ratio, and hence at a reduced cost of construction. It is not, however, easy to see where large further improvements in turbine design are possible, though we may note that there is one open point in steam turbine design which requires experimental elucidation, viz., the best blade spacing. Excellent results have been secured with water turbines in which the number of guide blades has been reduced to less than one-half the number which was standard practice a few years since. At the same time the "geometric" angle of discharge has been reduced. We believe we are correct in saying that this matter has not escaped the attention of the Nozzles Research Committee of the Institution of Mechanical Engineers, but pressure of other work has caused the postponement of this particular inquiry.

## THE PORT OF LONDON.

THE Port of London Authority came into being only fourteen years ago, when it took over a very miscellaneous collection of docks, which, in course of years, had greatly deteriorated relatively to shipping requirements. One of the best-advised steps taken at the time was to institute a thorough survey of the whole port with a view to determining the best means of putting it into a better state to attract vessels plying in important trades, instead of relying upon the patronage of miscellaneous tonnage. This survey resulted in a very comprehensive report by the Port's chief engineer, Mr. Frederick Palmer, which set forth a long programme of suggested improvements. The proposals then put forward were reviewed in our columns at the time.* They embraced a considerable increase in the warehousing and transhipshed accommodation, but the most important part was concerned with making provision for the use of the port by vessels of deeper draught than were then able to come up the river. This included a large amount of work on the river itself on which the sum of 750,000*l.* has been spent in the intervening years. The channel now available gives a depth at low water of 30 ft. as far up as the Royal Albert Docks, of 20 ft. between the Royal Albert and the Greenland Docks, while, after a stretch at 16 ft. depth, 14 ft. are available up to London Bridge. The channel alone, however, would be of little service to vessels without adequate dock accommodation. The most obvious way of improving this expeditiously, Mr. Palmer pointed out, was by raising the level of the impounded water.

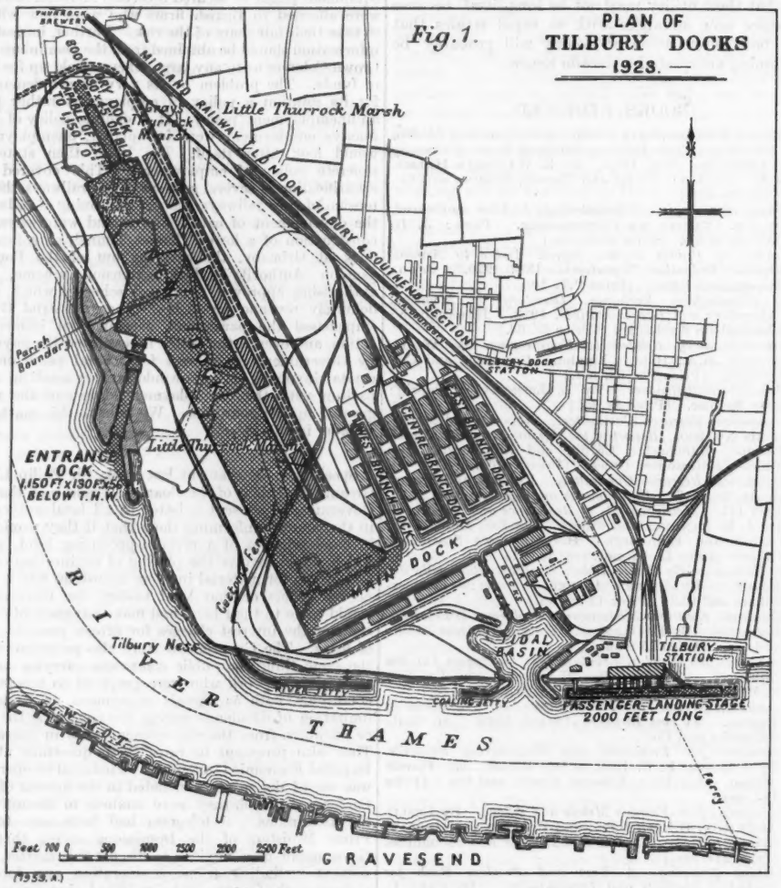
Such impounding by pumping was proposed for the London Docks, where pumping plant has since been put down to maintain the level in the Eastern Dock at 25 ft. 6 in., and in the Western at 24 ft. 6 in. This in each case was an increase of 4 ft. 6 in. Including, as well, sheds and a new jetty and deepening the passage connecting the two basins, the work at these docks has cost 300,000*l.*

At the West India Docks, Mr. Palmer's proposals have not been completely carried out, but at the cost of 300,000*l.*, new quays and transhipsheds have been provided. In the case of the East India Docks the water level has been raised from 26 ft. to 28 ft. by the provision of pumping plant. In addition extra quay accommodation and shedding has been provided. The changes carried out at the Royal Victoria have resulted in the deepening of that dock by pumping, from 25 ft. 6 in. to 28 ft., and in the case of the Royal Albert Dock similar proceedings have provided an available depth now of 29 ft. 6 in., against the former 27 ft., the depth in the basin being now 34 ft. 6 in., also 2 ft. 6 in. greater than formerly.

A number of other works contributing substantially to the improvement of the docks have been carried out, such as cold stores for meat, the improvement in this class of accommodation having led to a marked increase in the port's traffic in specialised trades.

The two most important single new works have been, perhaps, the construction of the King George V Dock, which has been illustrated and described in our columns,* and the enlargement by 17 acres of the main dock at Tilbury, a depth of 42 ft. 6 in. being provided. Many of this large series of improvements have, of course, been carried out under Mr. Palmer's successor, the Authority's present chief engineer, Sir Cyril Kirkpatrick.

*Fig. 1.*



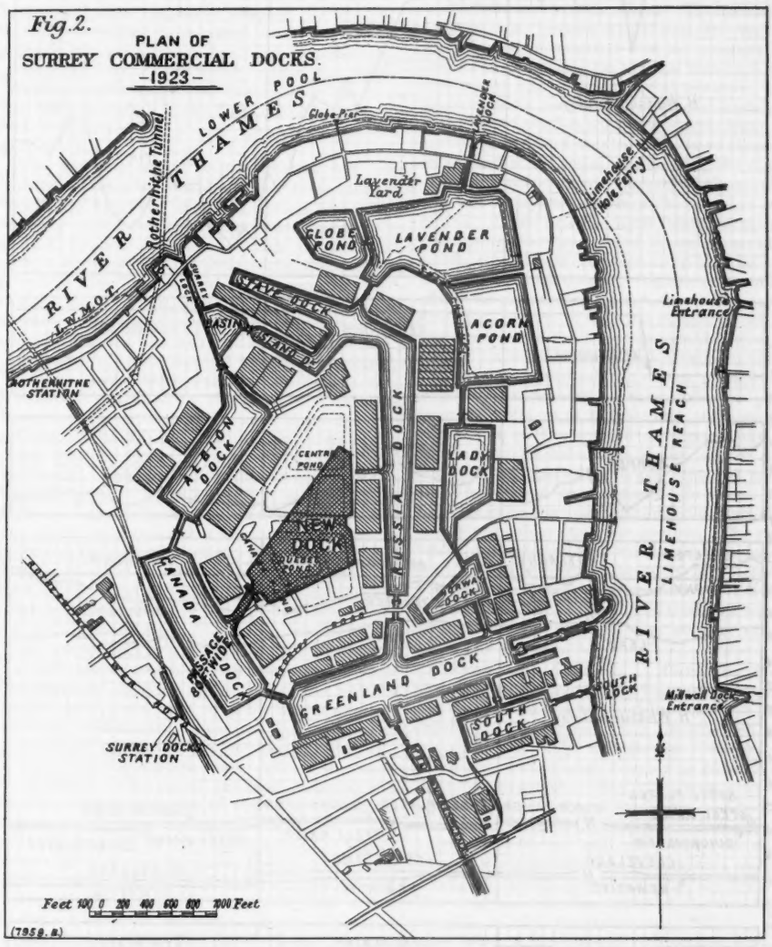

At the time of Mr. Palmer's report the ultimate programme which was of a farsighted character, contemplated new works of a very imposing scale. Already one of them, the King George V Dock has been completed, and improvements have been carried out at Tilbury. In anticipation of an increase of traffic the Authority has now decided upon still further work. The provision of the proposed 126-acre dock at East Ham is apparantly not being pursued for the moment, but it was announced last week that the Authority had decided to put in hand without delay the further enlargement of the dock area at Tilbury. This work will be, so far as the main water area of the new dock is concerned, substantially on the lines proposed in the report of 1911, but in other respects there are important modifications. The main dock will be 750 ft. wide, as originally proposed, and about 6,550 ft. in length. It will extend practically from Tilbury to Grays, and is shown on the accompanying plan. Fig. 1. The depth of this large area will at first be 40 ft. To enable this work to be undertaken the Authority will have to

* ENGINEERING, vol. xci, page 149.

* See ENGINEERING, vol. cxii, page 2.

acquire a considerable area of land. The entrance lock which it is proposed to construct will be rather larger than was originally proposed, while its lie with regard to the river has been modified. Originally it was planned to debouch into Northfleet Hope, and to run almost due east and west. This would mean that vessels leaving the dock would first point up-stream. The old location of the lock was at the heel of the whole dock area, where it might conceivably have served both the additional and the old sections of the dock. However, from Fig. 1 it will be observed that it has been considered expedient to change the location to one further along the dock side, and to alter the lie so that it will be approximately north and south, and will face down-stream. At the same time the straight run of quay wall will be broken by an offset which will give a good manœuvring space to vessels passing through the lock. Two dry docks which formerly were planned

*Fig. 2.*




but it made reference to the fact that certain projects had been roughly formulated. Conditions of the timber trade have been modified in the last twelve years, and the use of ponds for storage has been largely abandoned. The trade is seasonal, and considerable congestion of shipping occurs when the traffic is at its height. The present proposal is to construct a new dock in the heart of the area on the site of the present Quebec, Canada and Centre Ponds. This will afford accommodation for five additional ships, each 400 ft. long. The proposal is shown in the plan Fig. 2, the new dock having connection with the present Russia and Canada Docks. The passage to the latter will be 80 ft. in width. The depth of water will be 27 ft., with provision for carrying this ultimately to 35 ft. Further, in order to get better service out of the older portions of this system of docks, an impounding pumping plant will be installed so as to maintain the water permanently at spring tide level. The discharging space and storage will be increased by about 10 acres of shedding, and mechanical equipment for handling the timber will be installed. It is also hoped that railway connection with these docks will be arranged. It is understood that a more extensive scheme of improvements will follow in instalments later.

close to the old site for the entrance lock have now gone from the proposals. Before, they conveniently occupied a piece of suitable land, which, now that the lock has been shifted can be better applied to berthage, &c. In their place it is proposed to make, at the end of the new dock a single dry dock, 800 ft. long by 130 ft. wide, capable of extension at a future date, if necessary to 1,150 ft., this being the length which it is proposed to make the entrance lock now. The dock is expected to take five years to complete.

In the past few years as is well known a 1,000-ft. jetty has been erected at Tilbury close to Tilbury Ness. It is now proposed to proceed with the floating passenger landing stage in which the Authority and the London, Midland and Scottish Railway are co-operating. This floating stage will be 2,000 ft. long and 80 ft. wide, and a new railway station will be built close to it.

Another important project concerns the improvement of the Surrey Commercial Docks. The property of the Authority at these docks covers about 370 acres, most of which is cut up by small docks and ponds which are used in connection with the timber trade. In 1911, when Mr. Palmer's report was issued, it contained no proposals for any developemnts at this part, as its needs were not then considered to be pressing,

When making the announcement of these proposals last week, Lord Devonport stated that it was estimated that the present programme would cost about 5,000,000*l.* It would be partly undertaken in connection with the object of providing employment, and in consideration of this an arrangement had been made with Government for a loan of 4,500,000*l.* at 3½ per cent. interest for a term of thirty years.

## HYDRO-ELECTRIC POWER STATION FOR THE CITY OF YORK.

ALTHOUGH, apart from some favoured districts in Scotland and Wales, the water power possibilities of Great Britain are comparatively small, none the less considerable attention is being paid to such streams and falls as we have, and a number of interesting hydro-electric stations have been established in various parts of the country. They are necessarily in general of very moderate size, but may none the less furnish useful supplies at a cost which present prices of fuel make quite attractive. Stations of this kind have been established in connection with the municipal supplies of Worcester and Chester, and a further installation has now been made by the York Corporation, whose new hydro-electric station was opened by Princess Mary and Viscount Lascelles on Wednesday last.

This latest addition to the hydro-electric stations of the country is situated at Linton Lock on the River Ouse about 11½ miles north-west from York. The river has a discharge varying from 50,000 cub. ft. a minute in dry periods to 200,000 cub. ft. a minute in wet months, the average discharge being round about 100,000 cub. ft. a minute, and as there is a fall of 8·83 ft. at the point at which the station is built some 1,200 h.p. are available. It is estimated that in years of normal rainfall 2,750,000 kw. hours of energy will be produced. At the site of the old lock there is an island formed between the river and an artificial cut on which the lock is situated, and the station has been built on the river side of this island, so that the lock and navigation cut have not been interfered with in any way. An old weir, built some 100 years ago, runs across the river on the opposite side of the island from the lock, and the water is led to the forebay over this weir. In order to maintain the river at its correct level to furnish the working head, automatic weir shutters have been constructed in connection with the weir. They are controlled by counterweights made of pumice stone concrete and automatically rise and fall to suit the water conditions. In time of flood they open and allow the flood waters to pass, rising again as the river goes back to its normal flow. An old fish ladder on the opposite side of the weir from the power station has not been interfered with by the installation of these shutters.

The island site of the station proved to consist of very soft silt below water level, and much difficulty was experienced in getting foundations down below the river to the requisite depth. The power house has accordingly been constructed on 110 ferro-concrete piles, which go down 60 to 70 ft. below the normal ground level, while the building itself is also of ferro-concrete. The foundation walls of the head and tail races are of the same material, considerable difficulty has been encountered in their construction owing to running silt. It has been necessary to ensure that danger of water finding its way below the power house, through to soft silt should be eliminated. The water from the forebay enters the power house through strainer racks set at an angle in the usual way and passes to three main sluice gates, which control the three turbines. Of these machines two are of 430 h.p. and the third of 330 h.p. and by running one or the other, or various combinations, as may be dictated by the amount of water available, it will generally be possible to have the plant loaded to at least 72 per cent. of its capacity. The running schedule giving this condition is as follows :

| Plant Running. | Available Output. | Per Cent. of Full Load on Turbines. |
|---|---|---|
| | h.p. | |
| Small turbine .. .. .. .. | 0–330 | 0–100 |
| One large turbine .. .. .. | 330–430 | 77–100 |
| Small and one large turbine .. | 430–760 | 57–100 |
| Two large turbines .. .. .. | 760–860 | 88–100 |
| Three turbines .. .. .. | 860–1,190 | 72–100 |

It will be seen that the only case in which the percentage of rated full load will fall below 72 is in the region roundabout an output of 500 h.p., and, of course, the case of exceptionally dry periods. The arrangement adopted will result in the station working with an average hydraulic efficiency of 75 to 83 per cent. The small turbine has been specially designed to deal economically with small loads, and its speed is chosen to give a high efficiency over a long range of partial loads, so that the power station may work efficiently even when only small quantities of water are coming down the river.

The gate apparatus for each turbine consists of 20 cast-iron guide vanes which are 43·3 in. high for the large turbines and 35·5 in. high for the small one. They are pivoted at their ends in bronze bushes, carried by the foundation rings and are operated from above by levers and linkwork. The water enters the gates through concrete spirals which allows a higher water velocity and effects a gain in efficiency and a saving in space as compared with ordinary pits. The speeds of the sets are controlled by automatic or pressure governors, and both head and tail races are connected to a water level recorder in the power-house which traces on a chart the head under which the turbines are working. The vertical shafts of the turbines carry double-helical machine-cut crown wheels at their top ends, and the drive is transmitted

to the machines through double-helical machine-cut bevel gears.

The two large turbines drive a single 540 kw. alternator running at 60 r.p.m. and the small turbine drives a 210 kw. alternator at 75 r.p.m. Both machines generate 3-phase, 50 cycle current at 6,600 to 7,000 volts, and can withstand the runaway speed of the turbines which is about 1·9 times normal speed. The full load efficiency of the alternators is about 94 per cent., and taking 80 per cent. as the average efficiency of the turbines and allowing 2 per cent. loss in the bevel gears, the overall efficiency of the plant comes out at 74 per cent. The current leaves the station by a single feeder which is carried underground to York, supply being given to various villages on the way. The outgoing feeder and the machines are controlled by cast-iron switchgear of the draw-out pillar type. The whole scheme, including constructional, mechanical and electrical work, was carried out by The English Electric Company Limited of Queen's House, Kingsway, London, W.C.2, under the supervision of Mr. E. J. Nichols, the City Electrical Engineer. The turbines were built at the English Electric Company's Rugby works.

## WOOD-DESTROYING FUNGI IN COAL MINES.

People not actually in touch with coal mines hardly realise the scale on which timber is being utilised in such workings. The Forest Service of the United States estimated in 1905 that 200,000,000 cub. ft. of round and sawn timber were in use in the mines of the country and that they represented a value of 13,000,000 dols. The following import figures for the first eight months of the years 1913, 1920 and 1921 give an idea of the recurring needs of pit props and pitwood in this country. The imports, expressed in loads, were in round figures, 2,106,000, 1,273,000, 689,000, and their values amounted respectively to 2,636,000*l.*, 6,011,000*l.* and 1,951,000*l.* A striking feature in connection with these official figures lies in the large share that France continues to maintain in these imports; whilst countries other than Scandinavia and Portugal, contributed 928,000 loads in 1913 and only 57,875 in 1921, the figures for France were 673,000 and 419,000 loads.

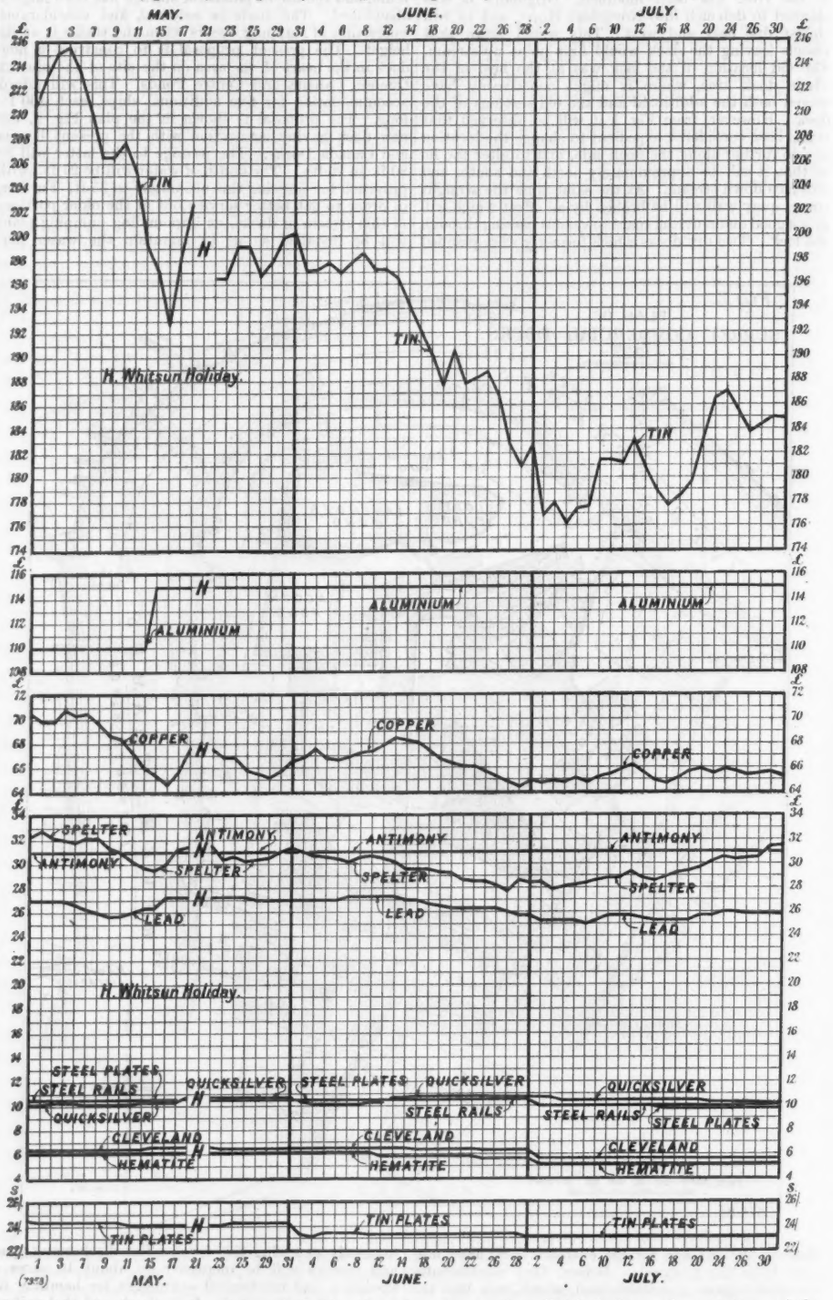
As regards the reasons for renewals of pit timber, the United States Forest Service ascribes 50 per cent. of the failures to decay by fungi and insects, 20 per cent. to breakage and fire, 5 per cent. to wear, and 25 per cent. to miscellaneous causes. How much of the breakage and waste is in its turn attributable to fungus decay it is difficult to say. That the 50 per cent. is hardly an over-estimate, however, is evident from Bulletin No. 10 of the Biotechnology Bureau of Messrs. Murphy and Son, of London and Leeds, which gives an interesting account of the way in which the fungus growth spreads. A rotten piece of timber much weakened by fungus, may appear sound, except that it looks a little cobwebby or mouldy in patches and gives a dull, hollow sound when tapped. The film, the mycelium of some fungus, consists of capillary tubes ramified like the nerves of a leaf which will creep up the stem and along the stone roof of a prop until they find another prop on which they spread. The mycellium may subsist for years without developing organs of propagation. More frequently it will send out small shoots like mushrooms, from the gills of which the ripe spores or germs are projected. When the mushroom grows in a meadow the spores fall on the ground. When the toadstool shoots out horizontally from a vertical prop it bends under its own weight, and the spores would remain caught in the inverted cap, if the head did not turn upward again, so that the spores can drop out. Air currents then distribute the spores which some toadstools and fungus produce by the millions per minute for days; no pronounced draught is required. R. Falck found that imperceptible convection currents carried the spores of the dry-rot fungus from the cellar of a house into all the rooms. Thus one diseased prop may infect a whole pit. In some cases the spores come directly from the surface of the fungus, which is perforated like a pepper box.

There are several kinds of fungus which attack pit timber, in addition to the dry rot mentioned. The *hypholoma sublateritium* resembles the yellow stump-tuft of our forests: the Dryad's saddle, *polyporus squamosus*, is common on elms; the rosy-tinted *trametes carneus* is so far unknown in our woods; the *coniophora puteana* forms a brown scablike growth on the props. The damage is done by the mycelium which penetrates into the wood and separates, destroys and discolours the fibres. A saw cut reveals that, and further, a tendency to longitudinal and also peripheral splitting which makes it difficult to cut fungus-eaten timber with the saw; the timber may be corded to keep it together, but it falls to pieces when the cord is taken off.

The decay of the timber by fungus growth may be rapid. Stems of 12 in. and 15 in. diameter have been known to decay completely within three years in damp and warm mines; some props barely last a year, and subsidences in mining districts are partly ascribed to the failure of mine props. Such failures are particularly serious in the ascending drifts connecting different levels which may form the only way of escape in cases of heavy falls of roof or of damage to shafts. By proper impregnation the life of timber and specially of mine timber can much be prolonged. The Bulletin referred to merely mentions two wood preservatives without explaining their nature or discussing the preservation problem. Both these preservatives can be applied simply by dipping or painting; "sporocide" is recommended for relatively dry positions, "superol" for damper places. Miners used to have little belief in impregnation of mine timber. Oak, the favourite material, and ash core wood are difficult to impregnate, and when untreated last ten years and more. Pine wood has undoubtedly been improved by impregnation, but smelly tarry materials are objectionable under ground, and expensive processes are out of the question. Props of the common acacia (*robinia pseudoacacia*), previously used in vineyards, were said to answer in Rhenish mines before the war. It is rather striking that the most approved agents and processes for wood impregnation have been with us for nearly a hundred years; the uses of copper sulphate, of zinc chloride, and of mercury sublimate date from 1840 and earlier, and Bethell treated wood, after evacuation, with tar oil from 1838.

## DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

*(Specially Compiled from Official Reports of London Metal Markets.)*




Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

The Liverpool Meeting of the British Association; Correction.—In our article on the programme of the Engineering, Section G, published on page 114 of our issue of July 27, we mentioned a paper on the "Distribution of Stress in Round Bars under Alternating Torsion and Bending." This paper, we understand, is by Professor William Mason, and not by Dr. Hubert Mawson, to whom we ascribed it.

## THE NATIONAL PHYSICAL LABORATORY.

(*Concluded from page* 122.)

*Electrotechnics. Alternating-Current Work.* (Dr. E. H. Rayner, Mr. R. Spilsbury, Mr. P. Mayne.)—Official and private work has kept the division so fully busy that the working hours have had to be extended. The plant for generating heavy currents at high volts and frequencies is being increased, and a duplication of the primary electrometer and electrostatic wattmeter is also contemplated in order to obtain information as to the suitable dimensions of such instruments. An electrometer is in use for power measurements at high potentials, especially for work on insulating materials; large clearances are kept between the working parts, and the whole system can be immersed in oil. The instrument was originally charged by means of mercury contained in a guard tube; but the wire dipping into the mercury was found to be subject to a torsional "sticktion" which, acting like friction, would give a false zero, to the right or left of the real zero, according to the direction of the previous last deflection. The use of mercury is therefore now avoided.

The examination of supply meters has been transferred from the Board of Trade to Teddington, which has approved of a few meters and is also studying the features of foreign instruments. The friction in the footstep bearings of watt-hour meters is investigated by determining the retarding torque in these bearings, which are generally made of gems, natural or artificial.

*Instrument Transformers. Non-inductive Resistances.*—Two years ago Mr. Spilsbury devised a new method of testing current transformers with the aid of an electrostatic wattmeter. He has since extended the method to the rapid and accurate determination of the ratio and phase-angle of potential transformers; the sensitivity realised is higher than is practically required, but the test is convenient. Standard non-inductive resistances are similarly tested. In this case the potential leads which are usually brought out to terminals, about 3 in. apart on the board, are apt to introduce an inaccuracy owing to the leakage field which, though small, cannot be disregarded in the case of resistances of large current capacity; this trouble Mr. Spilsbury has overcome by using a modified three-pin plug for the connections.

*Spherometer for Varnish Testing. Oil Switches.*—The dielectric strength of varnishes is generally determined by applying a thin film of the material to a flat metal plate (electrode), the thickness of the film being subsequently measured by an ordinary spherometer. Contact of the measuring point with the surface of the varnish being difficult to detect, Mr. Spilsbury makes use of the rapid damping of a vibrating reed as a means of detecting mechanical contact, as in the Ewing extensometer. The measuring spindle of the spherometer, a tripod, carries a small electro-magnetic buzzer, the vibrating reed of which forms the contact point; the winding of the magnet is connected with a dry cell and a telephone. As soon as the tip of the reed touches the varnish, the sound heard changes abruptly and then stops; readings can be repeated to about 0·001 mm., the minimum film thickness being probably 0·002 mm.

When oil switches are operated the arcs may liberate considerable amounts of gas and vapours from the oil and high pressures may be produced. This pressure has to be allowed for in the design. Dr. Rayner measures the maximum pressure with the aid of a range of gauges, steel pistons fitted with sharp points which are forced into sheet lead or copper. The instrument, the external dimensions of which are 35 mm. by 18 mm., can be suspended in the oil; pressures of several hundred pounds per square inch have been recorded close to the arc. Dr. Rayner's rotascope was described on page 659 of our issue of May 26, 1922.

*Direct Current.* (Messrs. S. W. Melsom, H. C. Booth, S. D. Anderson, W. E. Beer and P. J. Higgs.) *Buried Cable Research. Rating for Intermittent Currents.*—With the aid of an enlarged staff of his own and other divisions of the Laboratory, and in co-operation chiefly with Mr. E. Fawssett (Newcastle-upon-Tyne Electric Supply Company), Mr. Melsom has been able to carry his extensive research on buried cables, undertaken several years ago for the British Electrical and Allied Industries Research Association, sufficiently far to issue tables on Permissible Current Loading of British Standard Impregnated Paper-Insulated Cables in a report, drawn up by himself and Mr. Fawssett, which was discussed last spring in several meetings of the Institution of Electrical Engineers. Other papers had already been published, and the high character and importance of the work have been universally recognised. The value of the underground cables of this country is estimated at over 40,000,000*l.*, new cables are put down to the value of 2,000,000*l.* and probably 3,000,000*l.* per year, and the researches show that most of these cables might carry 10 per cent. higher loads; that means a possible saving of 300,000*l.* per year in cables. The theoretical and experimental researches involved are very heavy. They have demonstrated that the ordinary formulæ applied in calculating the thermal resistance of three-core cables may be wrong by 40 per cent.; capacity measurements made on electrostatic models (cables with shaped wooden cores) were alone found reliable for correcting the formulæ. The power losses in the cable, and the thermal constants of the dielectrics, of the protective coverings, and of the surrounding soil, wet or dry, cold or warm, have had to be determined. There was also little information available concerning the expansion of the cables and the safe temperature limits to which they may be exposed, the mutual influences of neighbouring cables, the effects on the current rating when cables are drawn into ducts or laid on the solid system, as well as the modifications of the rating permissible when cables are not loaded continuously at maximum current.

The tables issued refer to cables, of various sizes, single-core, concentric or three-core, for pressures from 660 volts up to 11,000 volts, suspended in air, laid direct in the ground or drawn into ducts. Separate tables have been drawn up for dry soil and for soil containing 5 per cent., 10 per cent., and 15 per cent. of moisture. So far as possible rules are given for predetermining the mutual effects of grouped cables upon one another. The rating of cables for intermittent or fluctuating loads has been especially reported upon by Mr. Melsom and Mr. Booth in a paper also presented to the Institution of Electrical Engineers last spring; this research mainly concerns the working of cranes, hoists and winches.

*Contacts in Bus-bars. Aluminium-Porcelain Resistance.*—The inquiry by the same investigators into the contact resistance of bus-bars and joints of aluminium and copper, has likewise led to the compilation of tables and graphs. Models, mostly of full size, were tested, varying as to surface condition, pressure and overlap; the parts were pressed together hydraulically or by clamps and bolts, bare or soldered with tin, or with tin-foil interposed. A report had further been prepared on the relations between the resistivity and temperature coefficients of samples of pure and commercial aluminium and their analyses. In the study of the resistance of porcelain at high temperatures (1,200 deg. C. and more) when softening and polarisation may come into play, the difficulty is to find suitable electrodes for the currents. This has been met, in one series of experiments, by utilising specimens in the shape of glazed or unglazed hollow cylinders, of the respective porcelain, which are filled with graphite.

*Photometry.* (Dr. Rayner, Messrs. J. W. T. Walsh, H. Buckley, A. K. Taylor.)—The integrating sphere-photometer, which we noticed in our issue of August 4, 1922 (page 134), has been much in demand, in conjunction with a new photometer bench for testing various lamps, from 5 c.p. up to 500 c.p., especially gas-filled lamps which, owing to their internal convection currents, cannot be standardised to the high accuracy of vacuum lamps. It is, on the other hand, to be regretted that few life tests have been required; there is reason to believe that large numbers of lamps are not really rated economically. The apparatus for obtaining the polar distribution of light from ordinary sources serves in this test work as an intermediate step between the international standards of light and the sphere-photometer which gives the value of the average intensity in every direction at one observation; this latter value (and not the horizontal value, so far commonly used and still retained for ordinary vacuum lamps) is being adopted for the rating of gas-filled lamps. In the polar distribution apparatus the intensity of light emitted from point to point in a vertical plane is determined by means of one or two mirrors which can be rotated. To secure a good average several zones of latitude, above and below the centre, will have to be observed, and it is convenient to make, as Dr. Alexander Russell does, the angles in a vertical circle such that the zones are all of equal area.

*Lighting of Factories and Buildings.* (Mr. Taylor.)—The experimental work conducted for the Home Office, involving a large number of illumination measurements in textile mills, has been completed. The Joint Committee on the Lighting of Public Buildings has recommended that the average illumination in rooms should not fall below 2·5 ft.-candles at any time. Experiments made in the Pensions Ministry Building at Acton, which is designed for a staff of 5,000, were chiefly made in a section of a room of 80 ft. by 37 ft. Fittings lent by various manufacturers were tried with gas-filled lamps of small and large powers; as a result the number of lighting points has been reduced by over 400, the saving in installation cost amounting to 1,000*l.*

For the badly neglected, general study of daylight illumination, a skeleton building has been erected on the Laboratory grounds. It is a glass-roof structure, 60 ft. by 30 ft. by 17 ft., supported on 8-in. by 4-in. stanchions. On the concrete floor of this building experimental rooms of a good size are erected, fixed to floor battens and provided with uralite walls, window openings (to be blocked by boards) and ceilings adjustable in height (up to 11½ ft.). Positions for the measuring instruments are marked on the floor, to admit of studying the effects of direct and indirect illumination, the proper proportion between height of windows and depth of room and other features. The building stands alone but a few trees at some distance off have a marked influence on the illumination curves.

*Metrology Department.* (Mr. J. E. Sears, Junior, superintendent; Messrs. S. W. Attwell, F. H. Rolt, E. G. Constable, F. A. Gould, V. Stott, G. A. Tomlinson, W. H. Johnson, W. G. Ridge, J. S. Clark, H. P. Bloxam.)—The staff has been further reduced in the sustained effort to bring the purely routine test work to a self-supporting basis. The industrial depression is reflected in the general reduction of almost every class of apparatus to be tested, except taximeters and engineers' gauges; both of these were exempted from the general increase of fees of 1921.

*Line Standards. Surveying Tapes.*—The outstanding feature of the work has been the assistance given by the Department (Mr. Johnson) in the decennial comparison of the Imperial Standards and their Parliamentary copies; Mr. Sears is deputy-warden of the standards at Westminster. The Laboratory nickel line standard No. 184 and the new platinised-bronze pound will be the principal Laboratory standards for British units. The bar Ni 184 was especially designed for a redetermination of the ratio of the yard to the metre; the legally-accepted conversion, 1 m. = 39·370113 in., has been confirmed within 1 in 2,000,000. The intercomparison of the 24-m. tapes and wires of the Laboratory and of Sèvres has finally cleared up the small remaining discrepancy in favour of the Laboratory. In 1911 the discrepancy was 4 parts in 1,000,000; later comparisons had increased it. In the standardisation of the four steel tapes in the 50-m. comparator the lengths are, as we mentioned last year (ENGINEERING, August 18, 1922, page 212), determined in terms of electric resistance and not in terms of temperature. The advantages of steel tapes (ordinary mild steel) over invar are confirmed; the former are more stable and less liable to damage; the 100-ft. steel tape No. 26, *e.g.*, has remained of constant length since 1911, whilst invar tapes have gained 7 or 8 parts in 1,000,000, in the course of ten years.

*50-metre Base.*—The temperature graph and length graph keep very fairly parallel; there is, however, a slight temperature lag, the bench continuing to

increase in length when the temperature falls after warm weather, so that the bench length cannot be accurately determined from the temperature in the corridor of the mural bench. Observations on the whole bench and on 24 m. of it, moreover, show that the bench length fluctuates more rapidly at the ends than in the middle. In this comparison Mr. Attwell's length measurements by the aid of invar sag wires, 1·5 mm. in diameter, continue to prove very useful, and the sag wires are now the most valuable standards of long length that the Laboratory possesses; the sag readings are taken twice a day, within 3 minutes. It must not be understood, of course, that the fluctuations pointed out put the value of the mural base in question.

*End Measures. Expansion of Gauges. Flatness of Surface.*—Observations on rod gauges, conducted in two rooms differing in temperature by 15 deg. C., substantiate the suspicion that the gauges have not all of the same expansion coefficient; differences of $1{\cdot}5 \times 10^{-6}$ per degree Centigrade have been noted. Gauges should be of the same coefficient, and subdivisions be made at the constant temperature of 62 deg. F.; a special room is being provided for this purpose. Mr. Rolt's optical arrangements for determining flatness and parallelism of gauge surfaces were noticed on page 159 of our issue of July 22, 1921; the arrangement of the interference apparatus in which the rod is turned about its vertical axis and the interference bands are observed in monochromatic light (mercury lamp), is in regular use.

*Wringing and Wear of Gauges.*—In this apparatus, as in many others, the gauge is wrung on to the base plate, and experiments have been made to determine the constancy of the liquid film between the two surfaces, the thickness of the film formed by various liquids and the amount of wear caused by the repeated winging operations. Twelve new gauges, nominally of a combined length of 2 in., were selected, carefully cleaned and wrung together several times, first without introducing any liquid film; the measurements were then repeated with films of paraffin oil, petrol and vaseline oil, the numbers of wringings amounting in each case to 180. The length of the combination gradually diminished in all cases, which must be attributed to a wear of the gauges, amounting to a maximum of 0·00003 in. Considering that the wear was distributed over 22 wringing surfaces, the wear was very slight, and the curves were all similar. The wear was most marked at the beginning of the tests and diminished asymptotically; that indicates that the surfaces are not absolutely smooth to start with, and that the original minute furrows, due to the lapping, are gradually worn away. With reasonable care the reduction in length of the combination should not amount to more than 0·000005 in. As regards the thickness of the films, the experiments showed hardly any difference between the inavoidable moisture film and the films of paraffin and petrol; the vaseline oil film seemed to be by 0·000001 in. thicker than the others.

*Screw Gauge Measurement.* — When effective diameters of small screws are measured with the aid of needles pressed into the recesses, the elastic compression of the needles has to be taken into consideration, and it has been found that the measured size of a No. 10 B.A. screw, measured with a pressure of 1 lb., has to be increased by 0·00015 in.

*Contact Indicator.*—In several measuring machines of the Department the position of a small circular sector is observed by moving the face of a micrometer forward to approach the sector. With strong illumination, Mr. Tomlinson finds readings can be repeated within 0·000001 in. As the sector and plane face approach one another, the slit between the two, after turning dark, appears in a series of spectral colours and passes through that series several times before actual contact occurs. This effect may be utilised in high precision measurements. As regards electric contacts, Mr. Tomlinson makes use of the grid circuit of a three-electrode valve altering the grid potential which produces a readily-observed change in the anode circuit; the minute current passing through the contact is magnified by the valve. Relays can be operated by these means with a travel of the tongue of only 0·001 mm.

*Gear-Measuring Machine.*—Mr. Tomlinson's noteworthy new gear-measuring machine was fully described and illustrated in our issue of last week (see page 104 *ante*).

*Physical Instruments. Barometers.*—The equipment of this section has been enlarged. Two airtight iron chambers, of several cubic feet capacity, have been set up to serve as pressure and vacuum chambers for the barometer testing; the Geryk pump exhausts the one chamber while pumping into the other. The new mercury barometer gauge (supplied by Messrs. Calderara) has been designed to read pressures in inches, millimetres and millibars; provision has been made to add a fourth scale for graduation in heights, but the engraving of that graduation will have to wait for the recognition of a settled basis for height scales. The experimental work on the experimental primary standard barometer of Mr. Sears has been resumed with very satisfactory results, and the design has now been decided upon.

*Weights, Balances.* (Mr. Gould.)—The continued researches on materials for standard weights confirm the superiority of platinum, against which there is only the high price and a relative stiffness. Of the possible substitutes, stellite (55 per cent. of cobalt, 35 per cent. of chromium, 10 per cent. of tungsten) is undoubtedly a very promising material as a working standard. It has stood air saturated with moisture, cold water, boiling water, acid fumes, oven treatment and some abrasion tests; but it is very hard, cannot be machined, and the final stability of all alloys is doubtful. So far a 50-gramme weight of stellite has not changed its weight (50·000404) by more than a few units in the fifth decimal within two years, though submitted to the tests just mentioned for days or hours. The other materials are, in descending order of merit: Tobin bronze (which can be rolled, and is more resistant to corrosion than brass), stainless steel (with 13·6 per cent. of chromium), and tungsten (rather disappointing when occasionally immersed in water). Weights made of these materials and platinised are also tested.

*Blythswood Diffraction Grating.* (Mr. Clark.)—The Blythswood ruling engine, originally made to the design of the late Lord Blythswood, and bequeathed to the Laboratory years ago, has had to undergo various modifications, but is now in use for ruling gratings, plane and curved (radius of 1 m.) up to 8 cm. (3 in.) in length with 14,000 lines to the inch. The "ghosts" in the spectrum have almost been eliminated by the provision of a new bearing and abutment for the screw, the original bearing having been found unsatisfactory. With the aid of an auto-collimator the screw, thrust abutment and bearing have been correctly aligned once and for all.

*The Rating of Watches and Chronometers.*—The decrease (150, against 220 in 1921) in the number of watches sent for trial is mainly due to the absence of entries for the Metropolitan Police tests, police tests of motor car speeds having practically been dropped in the Metropolitan area. The percentage of watches obtaining 90 marks and upwards was high last year (65·8 per cent. against 41 per cent. in 1921), but the proportion of failures was also high. The highest record of 96·8 marks was secured by the Zenith Watch Company, of London and Le Locle; all the highest marks were again taken by Swiss firms, and all the watches submitted were fitted with balances of the Guillaume or similar types, there being no entries of ordinary "brass and steel" compensation balances. Of marine chronometers 134 were submitted (against 97 in the previous year), the highest number since 1913, and the performance was good; there were 15 per cent. of failures, the average percentage of failures of the last eighteen years being 27.

*Glass Volumetric Apparatus.* (Mr. V. Stott.)—The increased demand for tests of glass apparatus has also been sustained. On the initiative of the Director of the Laboratory, Sir J. Petavel, a Joint Committee for the Standardisation of Scientific Glassware has been formed. The re-standardisation of the Laboratory hydrometers has been entered upon, with the hydrostatic balance, described last year*, and detailed specifications of hydrometers for the Institution of Petroleum Technologists have been drawn up; platinised glass hydrometers last better than gilded ones.

*Density of Air and of Sea Water.*—For the investigation of the density of the air a hollow sphere, of radius $a$, and a cylinder, open at both ends, of radius $a$ and length $a$, have been constructed of fused silica; the two vessels have approximately the same mass and superficial area exposed to the atmosphere; both are stiffened by diametral stay rods. The sphere displaces about 200 cub. cm. more air than the cylinder. The exact difference in displacement will be determined with the hydrostatic balance in air and in water, and from such determinations the density of the air in the balance case and its daily fluctuations daily are to be deduced; this would obviate the need of separate observations of thermometer, barometer and hygrometer in correcting weighings for buoyancy. The apparatus for determining the density of sea water, designed by Miss M. Knowles for the Ministry of Agriculture and Fisheries, does not claim any novel principle, but is convenient for use on ship-board, 15 minutes being sufficient for a test made with 150 cub. cm. of sea water and 5 minutes for the repetition of the test. The apparatus consists of a glass vessel, 9 in. high, of H-shape; the one tube contains a thermometer, the other a glass float. The vessel is nearly filled with the sea water, and then immersed in a bath which is slowly heated up. When the float keeps in stable equilibrium, the temperature of the sea water is read off; that temperature gives the density, a salinity change of $\pm$ 0·02 per 1,000 corresponding to a temperature change of $\pm$ 0·06 deg. C. The equilibrium temperature can be read within a few hundredths of a degree.

*Workshop Practice. Lapping.*—When we illustrated on page 230 of our issue of August 25, 1922, the lapping jigs of Mr. A. J. C. Brookes, who has since left the Laboratory, we did not draw attention to the point that the lapping plates are crossed by two systems of vee grooves, dividing the surface into small squares. The grooves are of a depth of $\frac{1}{32}$ in., the angle being 60 deg. or 45 deg.; in plates above, 12 in. diameter groups of four squares are separated by deeper grooves of square section. The object is to prevent the surface from becoming wavy, concave in the central portion and convex near the edge.

*Hardening and Normalising of Steel Gauges.*—The hardened steel end-measuring bars were found to change in size, soon after hardening, owing to the gradual release of the internal strain. They were, therefore, reheated to 170 deg. C., and allowed to

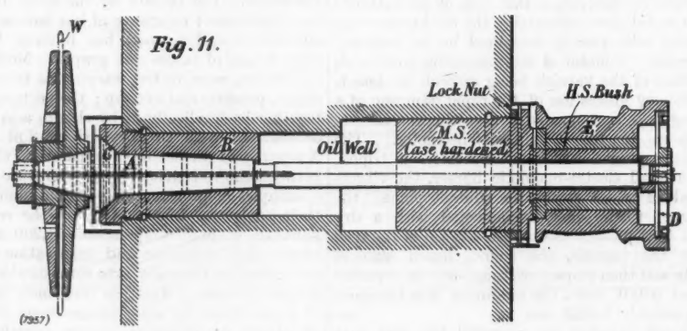
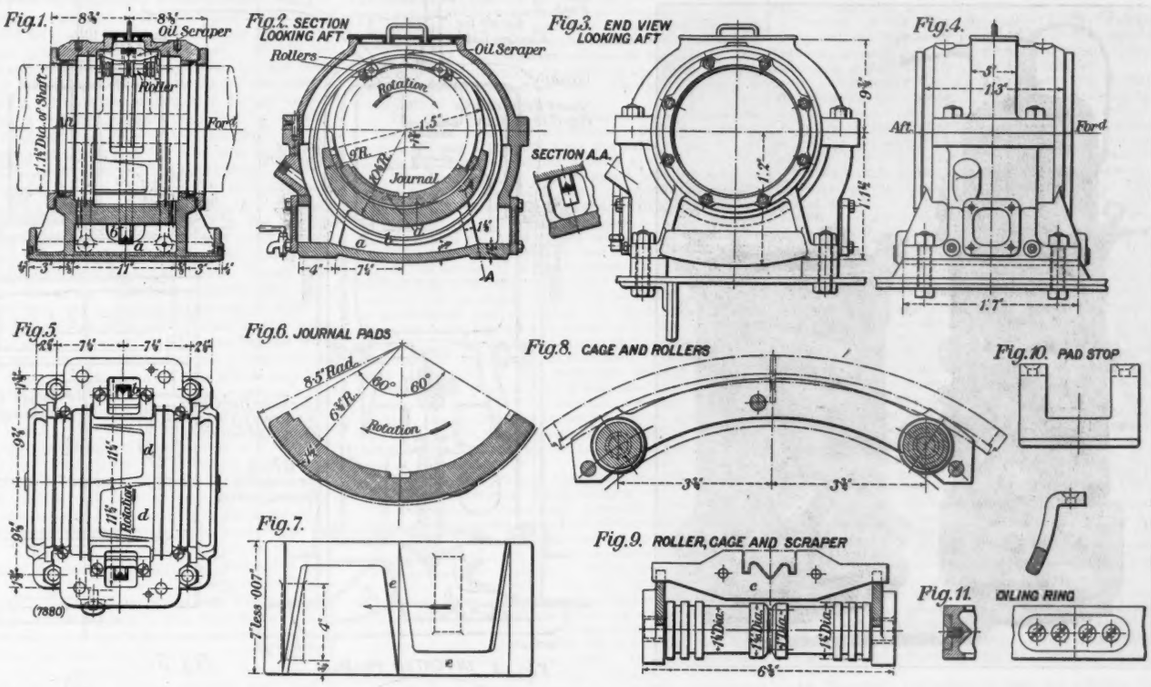


Fig. 11.

* Engineering, August 18, 1922, page 218.

# TUNNEL SHAFT BEARINGS ON THE MICHELL PRINCIPLE FOR S.S. "PHILOCTETES."

SCOTT'S SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GREENOCK.




tool in air; higher temperatures are inadvisable, because at 230 deg. tempering sets in. It was also hoped that this low-temperature treatment would correct the tendency towards slow secular changes of the finished bars, and so far the normalised bars, *i.e.*, bars hardened and then submitted to this treatment a year ago, are keeping constant in their dimensions during the year, whilst the merely hardened bars have slowly been contracting.

As a uniform hardening of long bars is very difficult to obtain, a special electric furnace has been constructed with the aid of which only a short length of the ends of a bar is hardened. The furnace is a vertical tube partly filled with mercury; the gauge is supported above the mercury, and on the top of the gauge are placed three blocks of graphite which are heated by alternating currents. In the case of a 1-in. gauge, 750 amperes is used for 2 minutes. The heat radiated from the lower block heats the top end of the gauge, from which it is separated by a piece of tinfoil; the gauge is then quenched in the mercury. The hardening penetrates to a depth of $\frac{1}{4}$ in. or $\frac{5}{8}$ in. into the gauge; on grinding the cylindrical surface, the hardened end can be sharply distinguished from the unhardened body of the gauge. The device is due to Messrs. Buckley and Bloxam.

*Grinding Screw-Threads.* — When hardened screw-thread gauges are made with the aid of formed grinding wheels, much depends upon the accuracy of the machine and upon the skill of the operator. The improved grinding wheel illustrated in Fig. 11 has been developed in the Metrology workshop; the length of the machine is 1 ft. The grinding wheel W is mounted on the overhanging end of the spindle A, which runs in the bearing B, and which has a taper of 1 in 20. The conical collar C locates the spindle against endwise movement and, being near the wheel, diminishes the effect of temperature variations in the bearing. The spindle is driven from the opposite end through the flexible steel disc D, fastened to the pulley E, which is mounted to revolve on an independent spigot bearing taking up the pull of the belt, thrusts and supports without lateral pressure on the spindle bearing. The flexibility of the long spindle obviates any detrimental effect of untrue alignment between the spindle and pulley bearings. Oil is fed from a central well and propagated by centrifugal action to either bearing. Grooves cut in the faces of the pulley thrust collars are of anti-throw off form and maintain an even film of oil over the collars; without the grooves the outer portion of the collars might dry up. Running at 4,000 r.p.m. or 4,200 r.p.m., on ordinary machine oil, the spindle temperature rises by 40 deg. or 50 deg. C. (70 deg. or 80 deg. F.). The M.S. and H.S. in the figure mean mild and hardened steel. The shrouds of the wheel are of aluminium, and they are interchangeable without impairing the running truth of the grinding wheels, a feature of consideration when several grades have to be interchanged on a single spindle.

## MICHELL BEARINGS FOR TUNNEL SHAFTING.

WE illustrate on this page an interesting application of the Michell principle to the lubrication of the tunnel shafting of the s.s. Philoctetes, built for Messrs. Alfred Holt, of Liverpool, by Scott's Shipbuilding and Engineering Company, Limited, Greenock. The Philoctetes has twin screw engines developing in the aggregate about 7,000 h.p., and the tunnel shafting is 13½ in. in diameter. For the purpose of making a comparison between the ordinary and the Michell bearings, the latter were fitted on the port side only, the ordinary type being fitted on the starboard side. Some adjustment and modification of the original design was found to be necessary in order to ensure an ample supply of lubricant to the pads. These modifications were made in consultation with Messrs. Michell Bearings Limited, of South Benwell, Newcastle-on-Tyne, and it is the drawings of the bearings in their final form which are represented in our engravings, Figs. 1 to 11.

As will be seen the bearings are of the self-lubricating pattern, an oil well being provided at *a*, as indicated in Figs. 1 and 2. From this well the lubricant is raised by the ring *b*, which is supported at the top on two rollers as best seen in Fig. 2. These rollers resting on the shaft are driven round by it, carrying with them the oiling ring. An enlarged view of the rollers is given in Figs. 8 and 9, and the latter figure also shows the scraper *c* by which the oil is removed from the ring and caused to drip continuously on to the rotating shaft below it. This shaft is carried by two Michell pads *d d* (Figs. 2 and 5). Of these an enlarged view is reproduced in Figs. 6 and 7. As shown both pads are pivoted so as to work best in the ahead direction of rotation, as it is found that no special provision is necessary for astern running, which is never sustained at a high speed for any considerable length of time.

The direction of rotation when the ship is steaming ahead is represented by the arrow in Fig. 6, and it will be seen that the points of support are well behind the centre of the pads, so that in ahead running the tendency is for the interspace between the pad and the shaft to open out at the leading edge in exactly the same way as occurs with the pads of a Michell thrust bearing.

One important feature, to which the success of the bearing is largely due, lies in the provision made for securing that the second pad gets its fair supply of oil. The leading pad gets, of course, ample lubrication as the shaft is covered with the oil dripping from the scraper. As the shaft passes over the leading pad, however, much of this oil is extruded. A further quantity escapes at the sides of this leading pad, so that unless special provision were made, the second pad would merely receive the exiguous residue escaping under the trailing edge of the leading pad. A Michell pad will carry almost any load provided it is fully lubricated, but under the conditions named the second pad would secure far from a full supply of oil, and could not be expected to carry its due load. To guard against this contingency Mr. H. T. Newbigin hit upon a plan which will be best understood by reference to Fig. 7, from which it will be seen that the bearing surface of successive pads is cut away on opposite sides alternately, thus providing a deep channel *e e*, by which the surplus oil which fails to pass over the trailing edge of the leading pad can still reach and lubricate the following pad. Until this type of pad was fitted the bearings of the Philoctetes gave a certain amount of trouble, but since the substitution they have proved extremely satisfactory, the temperature during a long voyage to Shanghai through the Suez Canal averaging only 18 deg. Fahr. higher than that of the surrounding atmosphere, as reported by the chief engineer to the ship.

The load carried is 153 lb. per square inch, but Messrs. Michell Bearings, Limited, have run similar but smaller bearings under loads of 1,000 lb. per square inch, and under this load the bearings ran quite cool. As indicated in Fig. 1 light packings are provided at each end of the bearing to prevent escape of the oil, and with this provision the loss of lubricant is very small and the bearings will run a very long time without requiring replenishment of the oil reservoir.

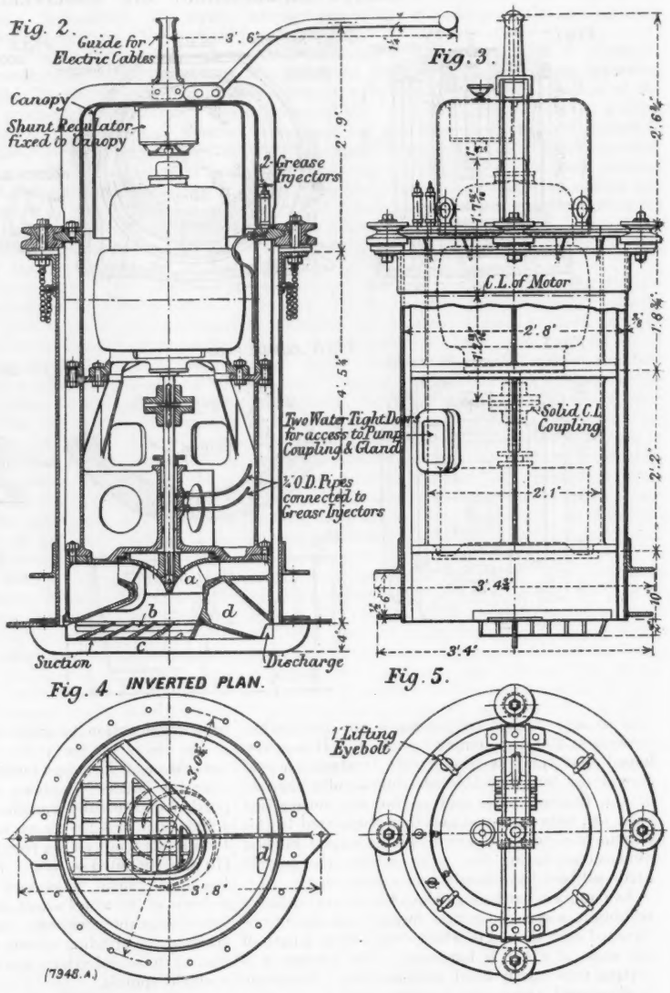
## JET PROPULSION FOR CANAL BARGES.

IT is common knowledge that no very high efficiency is attainable with jet propulsion, but efficiency must not be confused with effectiveness, and there are special cases in which the method is extremely effective,

# ELECTRICALLY-DRIVEN JET PROPELLER FOR CANAL BARGES.

THE GILL PROPELLER COMPANY, LIMITED, ENGINEERS, KING'S LYNN.

Fig. 1. Jet-Propelling Unit Complete with Motor.



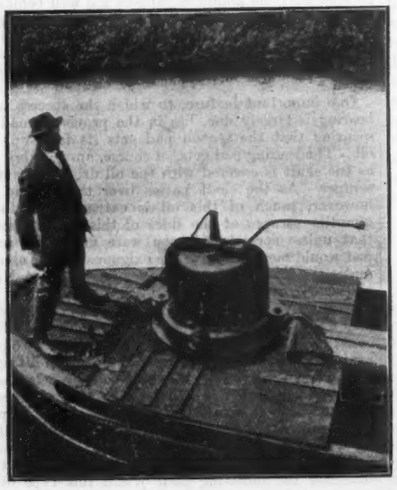



Fig. 6. Jet Propeller Installed in Place.

particularly where an extraordinary facility of manœuvre and a freedom from liability to fouling of the propeller. It was largely these considerations which led to experimental work with this system for barge propulsion by the Shropshire, Worcestershire and Staffordshire Electric Power Company for working barges on the Midland canals. As in other modes of transport, the "hay motor" is proving too expensive for modern conditions, and some method of propulsion by power has become essential. The company above-named have accordingly decided to install an experimental trolley line along a certain length of canal, from which the barges will draw current to operate propelling machinery. It was an essential condition that this machinery should be readily movable from barge to barge and that it should occupy a minimum of the "floor space," and that it should involve a minimum of projection beyond the skin of the boat. Full power manœuvring in any direction was also a desideratum and the plant had to be immune from weed troubles. A dead pull of at least 18 lb. per horse-power of input was demanded.

To meet these conditions the Gill Propeller Company, Limited, of 17, Victoria Street, S.W.1, and King's Lynn, Norfolk, designed a jet-propelling unit, which is represented complete in Fig. 1, and of which details are illustrated in Figs. 2 to 5 above; whilst Fig. 6

Fig. 7. View showing the Suspension of the Trolley Wire in an Open Reach.

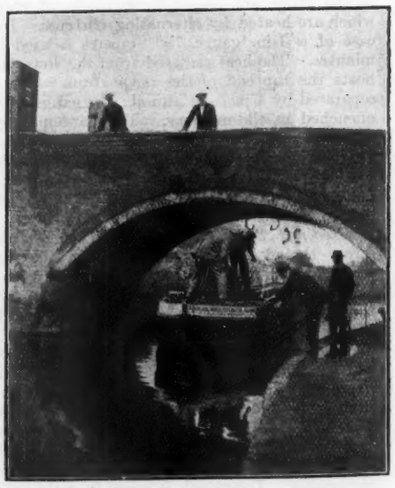


Fig. 8. Method of Carrying the Trolley Wire under a Bridge.

represents the unit installed in place in the stern of a barge.

A circular hole is cut in the floor of the barge, and the cylinder represented to the right in Fig. 1 is permanently fixed above this hole, making, of course, a watertight joint with the skin. The whole of the propelling plant is comprised within the cylindrical casing shown to the left, and can be lifted bodily into or out of the fixed cylinder already mentioned. Within this cylinder it can be turned freely by hand, friction being reduced by roller guides, as is perhaps best seen in Figs. 2 and 3. Inside the casing is a 18-h.p. electric motor with a vertical spindle, supplied by Electromotors, Limited, capable of developing 18 h.p. when running at 720 r.p.m. Below this motor, and coupled directly to it is a 10-in. centrifugal pump *a*, Fig. 2, designed by the Gill Propeller Company, and constructed by Messrs. Drysdale and Co., Limited. This can perhaps be even better seen in the inverted plan, Fig. 4. The inlet branch *b* for this pump projects very slightly below the bottom of the boat, and is fitted with a number of guide blades as shown. These have, however, a secondary object, as immediately below them is the steel bar *c*, ground on its upper edge like a skate, and this bar is permanently fixed to the barge. The latter is manœuvred entirely by rotating the whole propelling unit round bodily, and as a consequence, when the boat is steered, any weeds which may have become entangled at the inlet are cut in pieces by the scissors-like action of the guide blades moving over the fixed bar *c*. The outlet from the pump is at *d*, and a special design of volute chamber was necessary to convey the water from the pump to this point of discharge with a minimum of hydraulic losses.

A small 10-h.p. unit having been built for experimental purposes and operated over some hundreds of miles, the construction of the larger model was proceeded with, and this has been mounted as shown in Fig. 6, on an ordinary flat-bottomed wall-sided canal barge, 70 ft. long by 7 ft. broad, and rated at 25 tons nominal load. In tests runs made, near Kidderminster the normal speed of 3½ m.p.h. was attained with half-power, and when the barge was purposely beached on mud banks at this speed it was found that she could be pulled off again by exerting the full 18-h.p. of the motor. For a range of tests an average dead pull of over 25 lb. per b.h.p. has been attained with this set, without overload, and the manœuvring powers have been found excellent.

In Figs. 7 and 8 are shown the collectors and methods of supporting the trolley wires from which the current is collected. Though in this particular case electric power is employed a petrol motor could of course be used equally well, and has in fact been adopted in other installations.

## RECENT DEVELOPMENTS IN BALANCING MACHINES.*

By CARL RICHARD SODERBERG, East Pittsburgh, Pa.

THE balancing of rotating machinery is still far from being an exact science, although it has received a great deal of attention during recent years. Certain aspects of the problem still present difficulties. The balancing of small high-speed motors for domestic use has been neglected to a great extent because satisfactory balancing equipment has not been available. The necessity for balancing this type of rotating apparatus is continually growing with the increase in speed and capacity and the customers' demands for a lasting product. The present paper is a brief description of the efforts made to solve this pressing problem, and of the balancing machine finally developed that eliminated the difficulties and made it possible to manufacture quietly running motors.

2. Several fundamental difficulties, in addition to those encountered in balancing rotors of ordinary size, are involved in the problem of balancing small rotors.

(*a*) The balancing operation must be performed in a few minutes because the total cost of each unit is so low.

(*b*) The high speed necessitates a very accurate balance.

(*c*) The actual values of the centrifugal forces that are produced by a considerable unbalance are so low that it has been found extremely difficult to obtain an indicating device for the vibrating motion.

3. Because of these difficulties several attempts to produce a balancing machine for small armatures, operating on the usual principles of separating the static and the dynamic unbalance, have failed. It was decided, therefore, at the beginning of the investigation to follow a plan that would procure complete balancing in one operation, without previous static balance. Arrangements of this type have been used before, but in these the balance is obtained by three weights, two of which cause considerable inconvenience in computing.

4. It is shown in an appendix to the paper that the general state of unbalance can be corrected by two masses, one in each of two transverse planes of the body. This can easily be understood by recalling the fact that any system of forces emanating from a straight line may be counteracted by two forces.

5. The most common type of balancing machine now on the market consists of a vibrating table so supported on springs and a fulcrum that the table is capable of performing small vibrations around a fixed axis. On this vibrating member are mounted the rotor to be balanced, a "dynamical image" of this rotor, usually consisting of a variable couple, and a driving mechanism for rotating the body and its image. If the fulcrum axis is parallel with the axis of rotation the unbalanced dynamic couple is eliminated, and the static unbalance can be ascertained and corrected. By shifting the fulcrum axis to a position at right angles to the axis of rotation, the remaining couple will be effective and may be determined and corrected. In both instances the vibrating table performs a forced vibration under the influence of the unbalanced forces in the body, and the amplitude of this motion is increased by adjusting the speed of rotation so that resonance occurs. Thus the sensitiveness of the machine is magnified without undue increase of speed. The original dynamic balancing machine, the squirrel-cage machine devised by Akimoff* several years ago, was the first arrangement of this kind. Quite frequently the static balance is performed on parallel ways.

6. The static-dynamic balancing machine has the following fundamental disadvantages :—

(*a*) The static balancing generally increases the magnitude of the unbalanced couple because of incorrect longitudinal location of the correction weights. Thus the amount of balancing weights is greater than necessary.

(*b*) The number of places in which correction weights are applied is frequently four and cannot be reduced to less than three, while the theoretical mnimum is two.

(*c*) Any error in the static balancing will have a serious effect on the determination of the couple. The effect of residuary static unbalance is frequently magnified on account of the large moment arm. In order to obtain a balancing result with a certain tolerance it is therefore necessary to perform the static balancing with exaggerated accuracy.

7. With the disadvantages in the existing equipment and the special requirements for the balancing of small rotors, the following demands were made on the new type of machine :—

(*a*) Balance should be obtained by adding the theoretical minimum of weights to the body; that is, the two theoretical masses necessary for counteracting the system of unbalanced centrifugal forces should be given in the result.

(*b*) The balancing operation should be performed with uniform accuracy; that is, the effect of one mass should be eliminated while the other mass is determined.

(*c*) The balancing operation should take but a short time and be inexpensive, so that it can be applied to quantity production.

*Balancing Machine with Movable Fulcrum.*—8. Figs. 1 and 2 show diagrammatically an arrangement whereby the general state of unbalance may be obtained without segregation into static and dynamic unbalance. The body to be balanced is mounted in bearing blocks on a vibrating table supported by two spring members and a movable fulcrum member. This admits of motion around any axis in the plane F F at right angles to the axis of rotation. Assuming that the transverse planes A A and B B have suitable arrangements for the application of correction weights, it is certain, from the above, that any unbalance in the body may be corrected by one weight in each of these planes. By placing the fulcrum axis in one of these planes, say B B, the theoretical weight in this plane is eliminated as far as its effect upon the motion of the vibrating table is concerned. This will now be produced by the unbalance in the other plane.

9. If a counterbalancing device for measuring the amount and the angular position of this weight is added to the arrangement, the unbalance may be determined in the same manner as static or dynamic unbalance is determined in the old type of balancing machine. By subsequently placing the fulcrum in the plane A A the effect of the unbalance in this plane is eliminated, and the same procedure may be applied for determining the weight in the plane B B. It is evidently of no importance whether the balancing weights are applied during the operation or not, since the effect upon the vibrating table is reduced in each case to that of one unknown weight. It is also evident that this arrangement meets the requirements.

10. This arrangement, which has been called a balancing machine with a movable fulcrum, was adopted as the most suitable one for balancing small armatures. There is, however, no indication that its application will be restricted to small rotors.

*Features of the First Design.*—11. The subsequent design of an operative machine offered a number of interesting problems. There are two possibilities with reference to the operation of the device :—

(*a*) Determining the magnitude and the location of the unbalanced masses by means of a counteracting device.

(*b*) Determining the magnitude of the unbalanced masses by the amplitude of the motion, and the location by "cut and trial" or by "marking" the rotor.

12. Although these two systems are different, they have no bearing upon the following theories. The first model was built and operated in accordance with the second alternative mainly because unbalance on the type of motors for which the model was built could easily be corrected by inserting wedges into the slots. It seems probable that, in this particular case, no gain could be obtained in speed of operation by applying a counterbalancing device. The following principles relate to either one of these alternatives and will be discussed separately for the sake of clearness.

13. *Speed Variation for Different Locations of the Fulcrum Axis.*—Since the moment of inertia of the vibrating system varies with the location of the fulcrum axis, it is to be expected that the natural period, and hence the resonance speed, should vary. It has been found, however, that an arrangement can be made in which the restoring element receives a corresponding variation, so that the quotient remains constant. The theoretical explanation is given in a second appendix to the paper. The result of this investigation shows that if the two spring members are identical and located symmetrically with reference to the centre of gravity of the vibrating bed and at a given distance, the natural period of the system is independent of the fulcrum location. Fig. 3 gives an illustration of the principal for the specific case where the centre of gravity of the vibrating system is located in the fulcrum plane.

14. A constant balancing speed is very essential for efficiency and accuracy. The latter is largely dependent on the degree of resonance, and a slight error in the speed may distort the result altogether. The type of indicating device that was adopted served to increase the importance of constant speed.

15. Naturally the principle does not admit a variety of armatures to be balanced on the same set-up. As far as small rotors are concerned, they are manufactured in large lots, thus making it necessary to have a balancing machine for each type. When frequent changes have to be made, a vibrating table may easily be supplied for each type of armature.

16. *Indicating Device.*—The indicating device proved to be a stumbling block. Attempts to use the ordinary type of dial gauge indicators failed altogether. There was always the possibility of using the conventional mirror and light beam, but it was not considered practical in production routine. A vibrating reed was finally applied with success. Spring steel 0·125 in. by 0·006 in. is used on the present model and the amplitude of the reed is a tolerably good measure of the angular deflection of the vibrating bed. The resonance of a reed of this type is considerably sharper than the resonance of the vibrating table itself. This is a decided advantage, because erroneous readings are eliminated. It necessitates, however, a constant speed of the driving arrangement.

17. *Driving Mechanism.*—The requirements for constant speed magnified the importance of the driving motor. Several attempts were made with a small motor mounted on the vibrating table, but without success. The kinetic energy of the rotating masses must be sufficient to resist variation in the friction load. As long as the driving motor is mounted on the vibrating table, its weight must be restricted in order that the vibrating mass may not be too great. In the arrangement used at present the rotor is being driven by a fairly large alternating-current motor mounted on solid foundations. The driving belt consists of a silk ribbon. This arrangement has proved to be satisfactory. The disturbance of the belt is not sufficient to influence the motion of the vibrating bed.

18. *Predetermination of Sensitiveness.*—The problem of predetermining the amplitude for a given unbalance necessitates a closer study of the factors that limit the motion at resonance, and a better knowledge of the internal friction of springs is therefore of extreme importance. Little work has been done along this line, however, and there are no reliable methods available for the predetermination of the internal friction in springs. It is generally assumed that the damping of a spring is a linear function of the speed, and this appears to be fairly true for small motions. A variation of the spring characteristic for different degrees of compression will also limit the amplitude at resonance, although in a manner different from that of internal friction. If this variation is large it may seriously impair the resonance. The requirements of springs for balancing machines are therefore :—

(*a*) Straight-line characteristics.
(*b*) Low internal friction.

19. The relation of the amplitude, that is, the angular deflection of the vibrating bed, to the unbalanced moment is explained in a third appendix. It is shown that the angular deflection is directly proportional to the unbalanced moment with regard to the fulcrum axis and inversely proportional to the damping factor. This is

*Figs. 1 & 2. SCHEMATIC ARRANGEMENT OF BALANCING MACHINE*

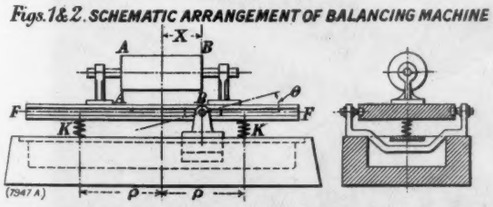
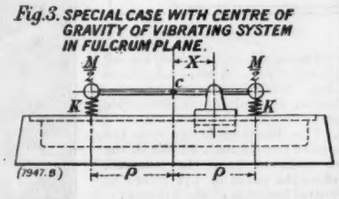



*Fig. 3. SPECIAL CASE WITH CENTRE OF GRAVITY OF VIBRATING SYSTEM IN FULCRUM PLANE.*




* Paper read at the spring meeting of the American Society of Mechanical Engineers held at Montreal, Canada, May 28 to 31, 1923. The Appendices are omitted.

* "Dynamic Balance," by N. W. Akimoff, Trans. A.S.M.E., vol. xxxviii (1916), page 367.

true for perfect resonance and for the assumption that the damping is proportional to the first power of the speed. It has also been found in this investigation that the major part of the damping effect occurs in the springs themselves. The total damping is therefore a function of the location of the fulcrum axis. The minimum of damping occurs at the central location of the fulcrum. Therefore the amplitude is not a direct measure of the unbalanced moment; it is always possible, however, to place the rotor in such a manner that the readings have the same value for the two planes in which the unbalance is corrected, because the variation of the damping factor is symmetrical with reference to the central location of the fulcrum.

20. There is, however, another factor of importance in this connection. It is theoretically true that if the balancing machines. They are influenced, therefore, by the following factors:—

(*a*) The nature of the indicating device.

(*b*) The damping factor.

(*c*) The actual value of the moment of inertia of the vibrating system with regard to the axis of oscillation.

22. The model with a movable fulcrum has an indicating device which records the angular deflection of the vibrating bed so that only the sensitiveness of this device (amplitude per radian) enters into the expression P/I. The other machines, however, are equipped with dial gauge indicators so that in the sensitiveness of the indicator is also included its distance from the axis of oscillation. This distance is usually made as large as possible. The larger machines therefore have the advantage of a more sensitive indicator. The dial gauge

a balancing machine with movable fulcrum adapted to balance an electric armature weighing about 9½ oz. Fig. 4 is a side view, Fig. 5 an end view, and Fig. 6 a plan. The machine is shown mounted on a working bench with a foot-operated starting and braking arrangement of the driving motor.

27. The vibrating bed A is supported by the coil springs B and the pivots C. These pivots engage in centres on the sliding blocks D so that by moving the carriage E the axis of oscillation is moved relatively to the armature. The location of the pivots with reference to the armature is indicated by the pointer S. One of the sliding blocks carries the vibrating reed $J_1$, which vibrates across the graduation on the scale G attached to the carriage E. The indications of the reed are therefore proportional to the angular deflection of the vibrating bed.

*Fig. 4.* SIDE VIEW OF BALANCING MACHINE WITH MOVABLE FULCRUM.

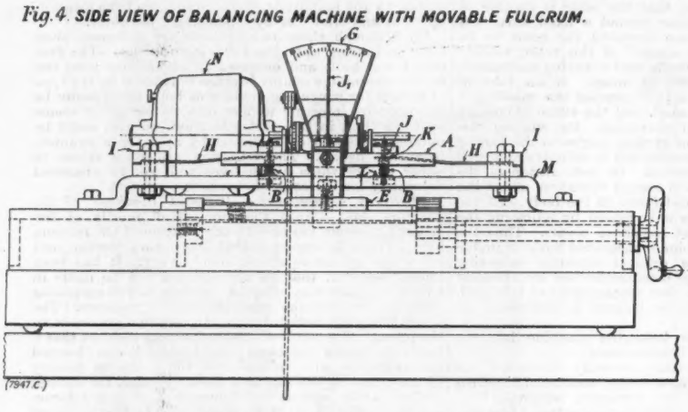



*Fig. 5.* END VIEW OF BALANCING MACHINE WITH MOVABLE FULCRUM.

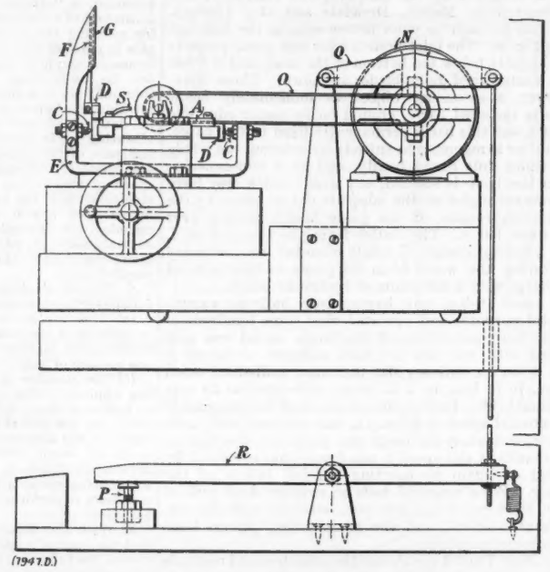
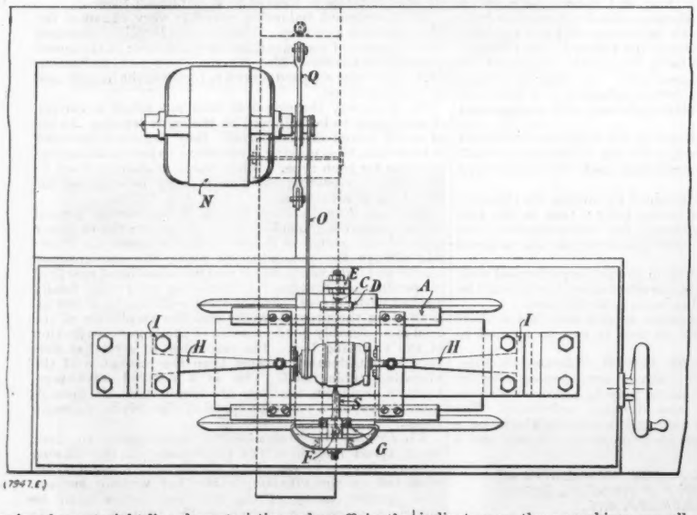



*Fig. 6.* PLAN OF BALANCING MACHINE WITH MOVABLE FULCRUM.



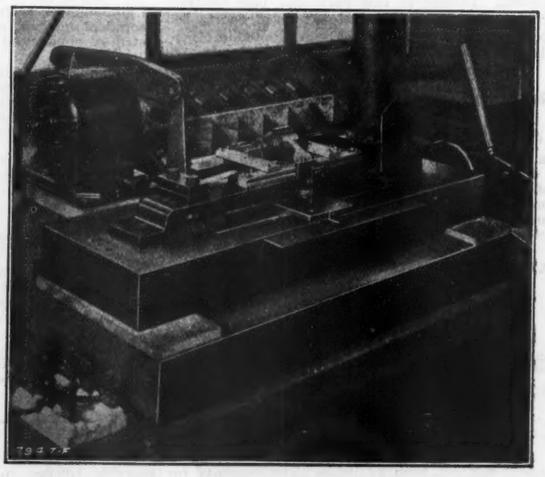




FIG. 7.

springs have straight-line characteristics and a sufficiently low internal friction, a small disturbance (unbalance) will produce a considerable amplitude. If the disturbance is small, however, the time required by the vibrating system to absorb sufficient kinetic energy to attain its maximum amplitude will increase. This introduces another element into the problem, namely, the proportion between the moment of inertia of the vibrating system and the magnitude of the disturbance. Common sense tells us that there is a certain limit to the moment of inertia of the vibrating system for each amount of unbalance to be measured, but no attempt has previously been made to establish actual values. In the author's opinion, the time required for the balancing machine to "pick up" and the amount of internal friction are the two elements that enter into the question of sensitiveness. It is shown in a fourth appendix that this time element is largely dependent on the quantity P/I; that is, the proportion between the unbalanced moment and the moment of inertia of the vibrating system. The minimum value of P/I will thus be a logical measure of the sensitiveness of the balancing machine. Below are given minimum values of P/I that were obtained in the model with a movable fulcrum and three other balancing machines of the usual type.

| | Value of $(P/I)_{min.}$ |
|---|---|
| 1. Model with movable fulcrum ... | $15{\cdot}0\times10^{-6}$ |
| 2. 125 lb. to 500 lb. balancing machine ... ... ... ... | $0{\cdot}6\times10^{-6}$ |
| 3. 500 lb. to 3,000 lb. balancing machine ... ... ... ... | $0{\cdot}45\times10^{-6}$ |
| 4. 3,000 lb. to 10,000 lb. balancing machine ... ... ... ... | $0{\cdot}4\times10^{-6}$ |

21. These values were obtained by experiments on the indicators on these machines are all of the same type. A total amplitude of 2 deg. (0·002 in. linear motion) is considered the minimum detectable motion.

23. The damping factor and the moment of inertia are variable in the model with a movable fulcrum. Therefore the value of P/I refers to the central location of the fulcrum.

24. The balancing machines in cases 2, 3 and 4 are of the same type. They show a tolerable consistency in the minimum value of P/I with a slight increase for the lower capacities. The model with a movable fulcrum has a capacity of an entirely different order and the value of P/I is increased correspondingly. This illustrates the difficulty in obtaining an accurate balance of small rotors. In order to keep the minimum unbalance sufficiently low it is necessary to have the moment of inertia of the vibrating system exceedingly small.

25. It would be highly desirable if the limiting values of P/I could be learned when a balancing machine is purchased. The buyer would than be able to tell if the lower limit is consistent with the accuracy of balancing that he wishes to obtain on the smallest rotor to be balanced. At the present time it is the practice to rate balancing machines with reference to the maximum and minimum weights of rotors to be balanced. The upper limit may be necessary from the point of view of stresses in the mechanical structure. The lower limit does not, however, give reliable information with regard to the accuracy of balancing.

*Description of First Model.*—26. Figs. 4, 5 and 6 show

28. The bed is prevented from moving in the horizontal plane by the flat springs H clamped in the blocks I. These flat springs press against the knife edges J which have centre pins engaging in centres on the caps K of the coil springs. The flat springs have slots to fit these pins. The slots are machined so that there is practically no clearance in the lateral direction but a considerable clearance in the longitudinal.

29. The coil springs are supported on the longitudinal member M by the adjustable seats L. Thus, the length of the springs may be adjusted so that the entire weight of the vibrating system is carried by the springs. In this case the pivots carry no other load than that of the inertia forces. The carriage E moves underneath the spring-supporting member M. This admits of moving the fulcrum member past the springs if desired.

30. The driving motor N is a single-phase induction motor starting as a repulsion motor. The load is very small so that it runs at its synchronous speed. The armature to be balanced is driven by the belt O. The

critical speed of the apparatus is about 1,700 r.p.m. The operating speed of the armature is 10,000 r.p.m.

31. The operation of this balancing machine is as follows: The armature is mounted in the machine, and the carriage E is moved so that the pointer S is in one of the transverse planes in which the unbalance is to be corrected. The treadle R is pressed down, thus closing the switch P and releasing the brake Q. The rotation of the armature produces vibrations of the bed around the fulcrum axis; the amplitude is a measure of the weight to be applied at the other end of the armature. This weight is recorded by the vibrating reed. The treadle is then released, stopping the driving motor almost instantaneously. The recorded weight is applied at an arbitrary location and the armature is again rotated. The second amplitude will indicate if this arbitrary location is correct or not. Three to four trials usually locate the weight correctly. The carriage is then moved into the plane where the first weight was applied and the same procedure is repeated.

32. Fig. 7 shows the same machine slightly modified. The vibrating reed is attached to one end of the vibrating bed. As a result of this, the reed does not record the angular deflection of the bed in a uniform measure for all fulcrum locations. This variation was found to be negligible, however. The production of this machine is about 20 armatures per hour at the present time. It may be increased considerably as the operator gains in experience. The accuracy of the balancing result is $\pm$ 0·00008 lb. at $\frac{3}{4}$ in. radius, the two balancing planes being 1 in. apart.

## CATALOGUES.

*Ozonair Ventilation System.*—We have received from Messrs. Ozonair, Limited, 96, Victoria-street, Westminster, S.W. 1, a booklet illustrating and describing the Ozonair ventilation system which has now been in continuous operation on the Central London tube railway since 1911. There are 12 separate plants installed at the different stations on the line, and these run on an average for about 15 hours every day of the year, supplying altogether some 110,000,000 cub. ft. of ozonised air daily. The annual cost of upkeep is given as 0·15 per cent. of the present cost value of the installation.

*Michell Thrust Bearings.*—We have received from Michell Bearings, Limited, of South Benwell, Newcastle-on-Tyne, a catalogue giving prices and dimensions of their standard patterns and sizes of Michell thrust bearings. The light or medium type is manufactured in 11 standard sizes for shaft diameters ranging from $\frac{3}{4}$ in. up to $5\frac{1}{4}$ in. in diameter, the corresponding maximum axial loads being 300 lb. and 11,000 lb. respectively. A heavy type is also manufactured, also in 11 sizes, for shafts ranging from $1\frac{1}{2}$ in. up to $7\frac{1}{4}$ in. in diameter, the latter being capable of carrying an end thrust of 38,500 lb. In a second catalogue a simple form of oil wiper or deflector is described, which is used to check the escape of oil over the ends of Michell thrust and journal bearings. The makers state that these deflectors have proved very satisfactory in service, and they supply them in seven standard sizes.

*Steel.*—A catalogue describing their "Vibrac" steel is to hand from Sir W. G. Armstrong Whitworth, Limited, Openshaw, Manchester. This is a molybdenum steel and is mainly suitable for machine parts subject to shock in addition to severe stress—such as gear pinions, connecting and coupling rods, crankshafts, &c.—and it will be of special advantage in aircraft and road motors where reduction of weight is of importance. The steel has two strong advantages in the working processes as compared with other alloy steels, including nickel chrome: (1) It leaves a clean smooth surface under the cutting tool, making structural defects easy to detect; (2) it is much easier to get the desired result and to get it uniformly in heat treatment. The general descriptive matter and data of tests stated in the catalogue are sufficient to claim a careful reading from engineers responsible for the design and the selection of materials.

*Gas Plant.*—We have received from Messrs. Robert Dempster and Sons, Limited, Elland, Yorkshire, a profusely illustrated booklet describing a complete gas-making plant recently completed by them for the Swindon Works of the Great Western Railway Company. The plant includes an installation of Dempster-Toogood continuous vertical retorts (with steaming) capable of carbonising 240 tons of coal a day and yielding 3,000,000 cub. ft. of gas, 170 tons of graded coke, with tar, ammonia, &c., according to the quality of coal employed. The coal-handling plant is capable of dealing with 100 tons per hour, and the coke-handling plant has a capacity of half this amount. Coke screening and washing plant, of ample capacity, has been installed, as well as breeze-briquetting machinery, gas-driven electric generating plant, and hoists for handling materials in trucks. The plant, which is actually the largest privately-owned installation of its kind, has been arranged so that the carbonising plant can be duplicated in the future, if necessary, without adding to the existing coal and coke-handling machinery. The illustrations in the booklet are mainly reproduced from photographs showing the plant in various stages of construction and also completed, but coloured sectional drawings are also included.

BRITISH EXHIBITION, AMSTERDAM.—A British Exhibition is to be held at Amsterdam, in the Palace of Industry, from January 10 to February 10, 1924. Full information regarding this exhibition may be obtained from the General Secretary, Mr. A. S. Veder, Prinsengracht, 1097, Amsterdam.

## "ENGINEERING" ILLUSTRATED PATENT RECORD.

### SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

*The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.*

*Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.*

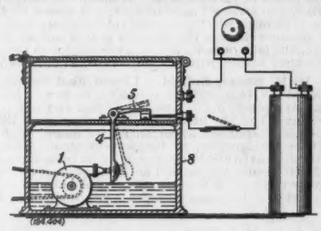
*Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.*

*The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.*

*Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.*

### ELECTRICAL APPARATUS.

**194,404. H. Deans, Port Tennant, Swansea, and W. J. Dixon, Gower, Near Swansea. Automatic Alarm Signals.** (2 *Figs.*) December 12, 1921.—The invention has for its object to provide an improved automatic alarm for signalling stoppage or the slowing down of machinery. According to the invention,

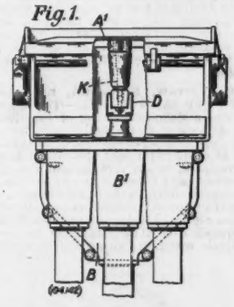


(194,404)

an automatic alarm comprises a contact member 4, 5, having a portion 4 dependingly supported within an oil chamber 8 containing a pump 1, such member being capable of hanging freely under the influence of gravity of being acted upon by a column of liquid forced from the pump. (*Sealed.*)

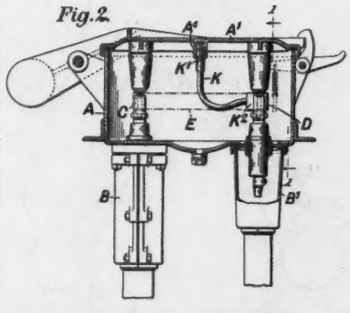
**194,142. Electrical Improvements, Limited, Newcastle-upon-Tyne, and R. W. Gregory, Hexham-on-Tyne. Electric Switch Fuses.** (3 *Figs.*) March 10, 1922.—The invention relates to electric switch fuses of the type intended for use on high-voltage systems. A switch fuse, according to the invention, comprises a box-like metal casing A adapted to contain oil and carrying a detachable fuse E on the inside of the lid A1. In the body of the box A are the fixed switch contacts C, D and terminals B, B1 for incoming and outgoing cables which enter and leave

Fig.1.



(194,142)

Fig.2.

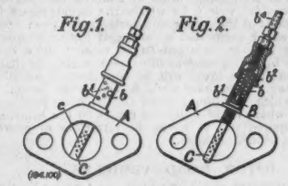



through suitable insulators or sealing boxes. In combination with the lid A1, which can open to give access to the fuse E at a safe distance from the fixed contacts C, D, is an earthing connection so arranged that when the lid is open the earthing connection can be adjusted so that on closing the lid a selected contact or terminal in the box is efficiently earthed. This earthing connection K is flexible and provided at one end with a plug K1 fitting into a socket A4 on the inside of the lid, and at the other end with a member K2 which can fit into or be attached to one of the fuse carriers. (*Sealed.*)

### GAS ENGINES, PRODUCERS, HOLDERS, &c.

**194,100. E. A. Pollard, Blackburn. Internal-Combustion Engines.** (4 *Figs.*) February 4, 1922.—This invention relates to a device of the kind in which a perforated pipe crosses the bore of the pipe between the carburettor and the induction pipe of the engine, or the induction manifold in the case of an engine having more than one cylinder, and leads to an air valve situated outside such pipe and controlled by a Bowden wire device to admit a variable supply of air through the perforated pipe. According to the invention, the perforated pipe C is carried by a plate A that is adapted to be clamped between the usual flanged coupling, which connects the carburettor with the induction pipe, and such plate also carries an air valve B that is situated outside it and controls the supply of air that is admitted through the perforated pipe which is attached to or formed in a piece with the air valve. The perforated pipe is advantageously perforated at one side only and arranged to occupy a position which will cause the additional air to travel in the same direction as the fuel mixture. The pipe C is formed in a piece with a cylinder *b*, and is screwed to enter a tapped hole in the plate A. In the wall

Fig.1. Fig.2.

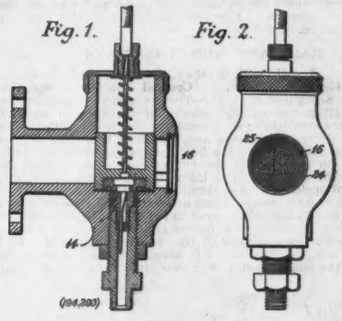


(194,100)

of the cylinder *b* are a number of holes *b*1. The air inlet valve B is situated in the cylinder *b* and comprises a piston that is normally retained at the inner end of the cylinder by a spring *b*2 and can be drawn away from such inner end by the inner member of a Bowden wire *b*4. When the piston occupies a position at the inner end of the cylinder it closes the communication between the holes *b*1 and the holes *c* in the pipe C, but by actuating the Bowden wire any number of the holes *b*1 can be opened, whereupon the suction in the induction pipe draws air through the cylinder *b* and through the holes *c* in the pipe C, with the result that such air is caused to be thoroughly mixed with the fuel mixture. (*Sealed.*)

**194,393. J. R. Hamilton, Enfield. Carburettors.** (4 *Figs.*) December 9, 1921.—The invention refers to carburettors of the kind in which it has been proposed to control separate inlets for fuel and for air to the carburettor and the mixture outlet from the latter simultaneously, to cover and uncover the inlet for the air and the mixture outlet by means of a single throttle, and to control the inlet for fuel by means of a valve movable with the throttle, the arrangement being such that the supplies of fuel and air gradually increase in constant proportions up to a certain

Fig.1. Fig.2.



(194,393)

point of operation of the throttle and valve, after which point further movement causes increase in the supply of air in excess. The improved carburettor provided by the invention comprises a needle or other tapered valve 14 for controlling the supply of fuel, and a valve controlled air inlet 16 having a main air supply portion 24 and an additional air supply portion 25 integral with the main supply portion, the main supply portion, which is first uncovered, being wide compared with the additional supply portion, which is of uniform width, or approximately so. (*Sealed.*)

**194,361. Edward Cockey and Sons, Limited, Garston, Frome, H. K. Hiller, Westminster, London, and J. F. Harrison, Partick, Glasgow. Washing and Scrubbing Gases.** (5 *Figs.*) December 3, 1921.—The invention relates to

Fig.1.

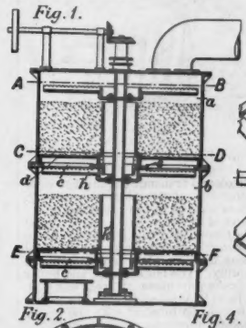



Fig.3.

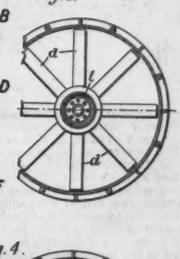
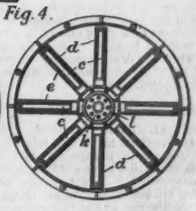



Fig.2.

Fig.4.



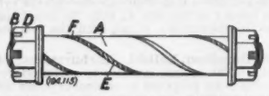
(194,361)

apparatus for the washing and scrubbing of gases in order to free them from ammonia, carbon dioxide, sulphuretted hydrogen and other soluble impurities. A number of compartments or chambers *a*, *b* are superposed. In the lower part of each are a number of

radially-disposed slots or gas openings *c*, each of which is surmounted by a hood *d* which is adapted to surround the slightly upstanding lip *e* on the slot, and the lower edges of which are provided with a number of serrations or openings through which the gas finds an outlet after bubbling through the seal of liquid in which the hood stands. The space in each compartment above the hoods is filled to any desired depth with porcelain rings over or through which the cleansing or purifying liquid may flow. There is provided in the upper part of each compartment just below the gas inlets of the next higher compartment, a series of radial trough-like arms *h*, adapted to receive the liquid over a central weir *i*, to which the liquid passes from the bubbling hoods of the upper compartment. Then trough-like arms are either perforated or arranged for an overflow of the liquid, and they are adapted to be rotated by a central vertical shaft *k* by which such members are carried, so that the liquid collecting in the arms will be conveniently distributed throughout the compartment which the arms serve. The weirs *l* over which the liquid flows to the collecting central member, from which it subsequently passes to the arms, serve to give the required seal to cover the serrations or apertures of the bubbling hoods. (*Sealed.*)

## MOTOR ROAD VEHICLES.

**194,115. M. V. Roberts, London, and The Light Production Company, Limited, London. Spring Suspension.** (3 *Figs.*) February 16, 1922.—The invention relates to shackle bolts used in motor road vehicles for connecting the free ends of the suspension springs. According to the invention the bolt is made from a solid rod A having screw threads B at one or both ends to receive securing nuts D. This rod is grooved longitudinally in the form of spirals at E and in these grooves is inserted absorbent material which is saturated with lubricant, advan-




tageously graphite and oil. The absorbent material for each groove may conveniently take the form of a wick F surrounding a central wire, so that the same can be readily inserted and withdrawn when the nuts are removed. One or both ends of the bolt is or are formed of reduced diameter, there being between the bearing surface and the screw-threaded part a shoulder into the surface of which the grooves E open, so as to permit the removal and insertion of the wicks without removing the bolt from the bearing. (*Sealed.*)

## RAILWAYS AND TRAMWAYS.

**194,332. J. Mitchell, Putney, London, and J. C. G. Cossey, Golders Green. Central Buffer Couplings.** (10 *Figs.*) September 12, 1921.—The invention concerns central buffer couplings for railway vehicles of the type in which a draw hook of rectangular cross-section slides in the buffer shank and transmits draft stresses to a spring placed behind the coupler head, which also takes up the buffing stresses, which are transmitted by an extension of the buffer head. According to the invention, the drawhook 3 is integral with a member entirely enclosing or enclosed by an extension 2 of the buffer head 1 on or in which it slides, and is guided under the draft stresses, one or more drawbars 7, 8 rigidly secured to the drawhook, transmitting these stresses to a draft and buffing spring 6 placed in a casing secured to the longitudinals of the wagon under-frame. In a preferred form, the drawhook 3 is adapted to slide on an extension 2 of the buffer head 1, and two draw-bars 7, 8 are sym-

*Fig.1.*

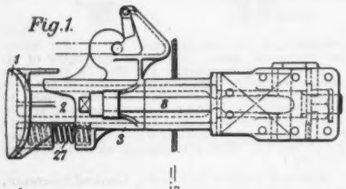
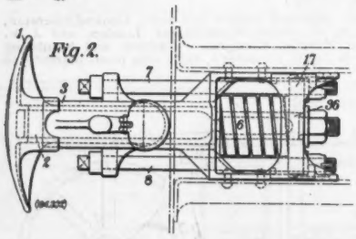


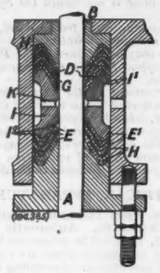

*Fig.2.*




metrically secured to the drawhook and transmit the draft stresses to a follower plate 17 forming one abutment for the spring. A buffer shank 36 integral with or secured to the extension of the buffer head, in case of any failure of the draw-bars secured to the drawhook, transmits the draft stresses. For this purpose, the two draw-bars and the other buffer shank engage through the usual nuts and cotters with the same follower plate which forms an abutment for one end of the spring. The buffer shank and buffer head with its extension are preferably made of steel castings. The extension 2 of the buffer head is adapted to slide through a limited space in a guide which may be integral with the spring casing, and the buffer head is kept in contact with the opposing head by means of a weak spring 27 interposed between the drawhook 3 and the head 1, in order to maintain the buffer faces in contact while the draft stresses are acting on the vehicles, thereby reducing recoil shocks when the engine pulls up or the brakes are suddenly applied. (*Sealed.*)

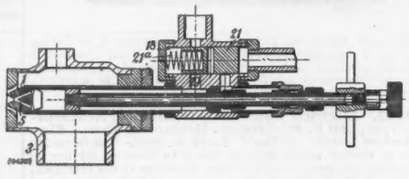
## STEAM ENGINES, BOILERS, EVAPORATORS, &c.

**194,385. H. Brier, Dartford. Packing.** (4 *Figs.*) December 9, 1921.—This invention relates to packing for the rods, spindles, pistons or plungers of air or gas compressors, pumps, hydraulic rams, fluid pressure engines, valves and the like. In accordance with the invention, the packing includes a series of leathers of truncated conical hat shape open at the truncated end to embrace the rod or the like and adapted to nest one over the other, with the small flange or brim at about right angles to the sides of the crown. A is the piston rod of a high pressure gas compressor. Interposed between the neck ring B and the gland are two series of leathers D, E of truncated conical hat shape open at the truncated end to embrace the rod A and adapted to nest one over the other with the small flange E1 or brim at somewhat less than right angles to the longer flange, and with sheet metal conical rings G interposed between the longer flanges of the leathers. These sheet metal rings G have a slightly larger inner diameter and a smaller outer diameter than the leathers D, E, and rings of rubber, leather or other material H are interposed between the leathers D or E and the rings G to make good or fill



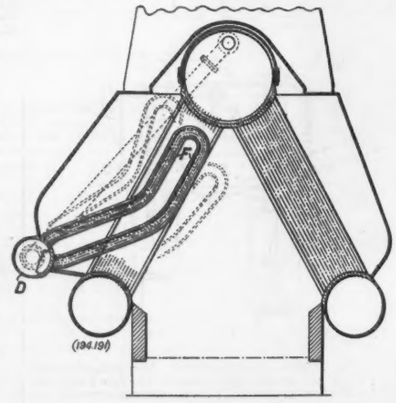

what otherwise would be vacant spaces. As shown the two series of leathers D, E are arranged apex to apex, and spaced by the usual lantern I, through which oil or suitable lubricant may be forced under pressure through the openings K into contact with the piston rod, the lantern being formed preferably with shaped ends I1, I2 to abut against adjacent leathers D, E. (*Sealed.*)

**194,383. D. R. Bruse, Enfield. Liquid Fuel Burners.** (3 *Figs.*) December 8, 1921.—The invention has to do with liquid fuel burners. According to the invention, liquid fuel is forced through the nozzle 1 of the burner through two or more independent passages 5 arranged at an angle, by means of fluid pressure. There are, however, no independent air or pressure fluid passages through the nozzle, the pressure fluid being admitted to a casing 3 surrounding the nozzle 1 and thus passing with the fuel jets into the furnace. A fuel concentrating chamber adapted to direct the fuel into the nozzle passages is provided behind the



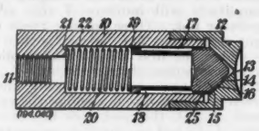

nozzle. The fuel supply to the nozzle is controlled by a hand-operated needle valve, and the pressure fluid is controlled by a second similar hand-operated valve. The fuel supply may be controlled by the fluid pressure in known manner so that when the pressure is cut off the supply of fuel automatically ceases. This may be effected by causing the fuel from the reservoir to pass through a port to a casing 18 controlled by a reciprocating piston 21 under the action of a spring 21a and the fluid pressure, the spring normally tending to close the fuel port and the pressure to open same. (*Sealed.*)

**194,191. H. E. Yarrow, Scotstoun, near Glasgow. Superheaters.** (3 *Figs.*) April 25, 1922.—The object of the invention is to secure a definite amount of superheat under varying conditions of working of the boiler, due, for example, to the varying quality or character of the fuel, or to an intentional change in the rate of evaporation, and this object is attained, according to the invention, by an arrangement of superheater which enables the superheater tubes to be swung into different positions within the furnace setting so that, for example, the tubes may be shifted from their normal position into one in which they are traversed by furnace gases of higher temperature if an increase in superheat is required over that obtainable in the normal position, or alternatively withdrawn into a position in which they



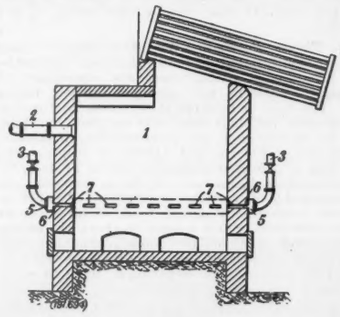

are traversed by furnace gases at a lower temperature if a lower degree of superheat is required. This change of position of the superheater tubes is obtained by so constructing the superheater that rotation of the superheater drum D about its longitudinal axis in one direction or the other serves to effect the desired change of position of the superheater tubes F. In the ordinary arrangement of water-tube boilers of the Yarrow type the superheater may be arranged either with the superheater drum at a relatively low level and the superheater tubes projecting upwards therefrom, as shown, or the drum may be at a relatively high level with depending tubes; such a superheater may be mounted at one side only of the furnace or there may be a superheater at each side. (*Sealed.*)

**194,040. W. A. White, Jesmond, Newcastle-on-Tyne. Liquid Fuel Burners.** (3 *Figs.*) December 29, 1921.—The invention relates to a burner nozzle for use in connection with liquid-fuel furnaces. According to the invention, the strainer forms part of the nozzle plug itself made to fit the burner tube so as to slide with respect to a portion only of its length at its rear and front ends, while the intermediate portion is slightly reduced in diameter so as to form an annular space between it and the burner tube. The burner tube 10 is screw-threaded at 11 to receive an oil-feed pipe. The opposite end of the burner tube is externally screwed to receive a cap 12 provided with a central delivery orifice 13 and inside with a conical or frusto-conical seating 14 to receive the conical end of the nozzle plug 15. The coned face of the nozzle plug is provided with tangentially disposed grooves 16, the outer ends of which communicate through channels 25 with an annular chamber 17 surrounding the nozzle plug. The forward end of the plug is of solid construction, whilst its rear portion comprises




a perforated sleeve-like member 18 having perforations arranged at spaced intervals apart and preferably in rows, which may be parallel, to strain the oil in its passage from the interior of the burner tube 10 to the annular chamber 17. The rear open end of the sleeve portion of the nozzle plug is provided with an annular shoulder 19, which is a sliding fit in bore 20 in the interior of the burner tube 10. The bottom of the bore 20 of the burner tube is provided with a shoulder 21 which forms a seating for one end of a coil spring 22, the opposite end of which engages the enlarged open end of the sleeve portion of the plug. The spring is arranged to press the forward frusto-conical end of the burner plug 15 on to the conical seating 14 on the interior of the cap 12. (*Sealed.*)

**191,694. The Powdered Fuel Plant Company, Limited, Westminster** (*The Assignees of Société Anonyme La Combustion Rationelle, Paris, France*). **Furnaces for Powdered Combustible.** (2 *Figs.*) April 3, 1922.—The invention is concerned with furnaces for the combustion of powdered fuel. According to the invention, a cold zone is formed between the ash pit and the flames by the projection of cold or slightly preheated air under pressure in a thin film or layer through openings formed in the brickwork of one or more of the walls of the combustion




chamber, level with, or just above, the top of the ash pit. The combustion chamber 1 is fed by the burner 2. Pipes 3 deliver air from a fan to distribution boxes 5 which are placed against or in the brickwork forming the walls of the combustion chamber. Nozzles 6 discharge into openings 7 in the walls of the combustion chamber. These openings are of rectangular section, elongated horizontally, so that the blast of air from the whole of the openings forms an actual curtain stretched horizontally level with, or just above, the ash pit. (*Sealed.*)

**193,949. R. Allen, Woodcote, near Reading. Metallic Packing.** (6 *Figs.*) November 29, 1921.—The invention relates to metallic packing for rods, shafts and the like, in which segmental packing rings are employed in conjunction with inextensible rings. A metallic packing constructed, according to the invention, consists of packing rings *a*, each divided into segments and pressed into close contact with the rod or shaft by

*Fig.1.*

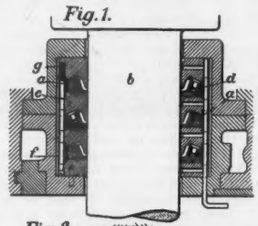
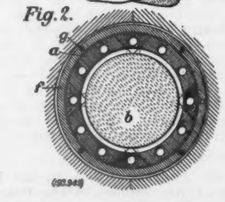



*Fig.2.*




springs *d*, inextensible rings *e* fitting closely to the rod or shaft *b* and placed thereon alternately to the segmental rings, and distance rings *f*, surrounding the packing rings *a*, and each fitting a recessed portion of two adjacent inextensible rings *e*, the whole of the rings being held together and made steam or pressure-tight by long screw-threaded pins or rods *g*. (*Sealed.*)